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TRENDS AND PROJECTIONS
IN EDUCATION FOR CERTAIN ENGINEERING SPECIALTIES:
CIVIL, MECHANICAL, ELECTRICAL AND ARCHITECTURE

By

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This report contains 129 pages.

I. INTRODUCTION

Engineering and science have been responsible ever since the invention of the wheel in prehistoric times for much of man's intellectual as well as material advancement. Century by century one or the other or both have added to knowledge and the ability to convert energy to useful work. Recently scientific and engineering contributions have been coming at such a fast rate at all levels that in a matter of only two decades civilization has gone through the nuclear era to the space age. Furthermore, there is every reason to believe such changes will continue with even greater acceleration.

Thus, America finds itself once again at a frontier--the intellectual frontier. A century ago characteristics which distinguished the pioneer were physical prowess, courage and bravery. Today, he must possess mental prowess, integrity and wisdom. He is the scholar, the scientist, the engineer and the teacher. In those years of long ago the people followed their pioneer leaders in wagon trains to help develop the primitive lands just west. Today, too, our citizenry must meet a challenge, the challenge of engineering advance.

The task, though difficult, is clear. Educate the leaders-to-be to a high dedication of learning in all fields and to practice of the Golden Rule, and cultivate a deep understanding between the public and the expert. The choice is simple, use nuclear energy to free man from drudgery or use it to make this discussion of engineering education and every other discussion useless.

II. ENGINEERING EDUCATION

A. The Past

Formal engineering education probably had its beginning in France in 1775 with the establishment of the École des Ponts et Chaussées. England founded its Royal Technical College of Glasgow in 1796 and Germany its first real technical school in 1833 at Karlsruhe. In the United States the Military Academy, which graduated its first class in 1802, became the first school of applied science in 1817 when Col. Sylvanus Thayer, who had studied abroad, became its superintendent. In 1823 Stephen Van Rensselaer founded a school in Troy, New York "for the purpose of instructing persons who may choose to apply themselves in the application of science to the common purposes of life."⁴¹⁶ Twelve years later in 1835 the Rensselaer Polytechnic Institute granted its first four degrees in civil engineering. The University of Michigan pioneered in engineering education in the then West, offering its first degrees in 1860. In addition, attached schools of science such as the Lawrence School of Science at Harvard and the Sheffield School of Science at Yale made their appearance in 1847.

The need for technical schools was felt strongly by our young, growing nation. Passage of the Morrill Land Grant Act of 1862 accelerated founding of schools emphasizing "agriculture and the mechanic arts" and also, the teaching of "other scientific and technical subjects." The Massachusetts Institute of Technology was started in 1865 "for the purpose of instituting and maintaining a society of arts, a museum of arts, and a school of industrial science, and aiding generally by suitable means the advancement, development, and practical application of science in connection with arts, agriculture, manufactures, and commerce."⁴¹⁸ Dartmouth and Cornell opened engineering colleges in 1867; Worcester Polytechnic Institute opened in 1868 with a scheme of shop training by actual production.

In 1871 the Stevens Institute of Technology was founded as the first school solely in mechanical engineering. Its institution resulted from an endowment of \$600,000 from Edwin A. Stevens, member of a family of early pioneers in railroads and steam power.⁴⁵² Among many other engineering schools founded in this early period were Purdue in Indiana in 1876, Georgia Tech in

the South in 1888 and Stanford in the Far West in 1891. The Wickenden report⁴¹⁷ covering an extensive investigation of engineering education conducted between 1923 and 1929 contains the following statement concerning early American efforts:

In 1866 there were but six engineering colleges of established reputation and but 300 men had been graduated in the previous thirty-one years. By 1870, . . . the total number of engineering colleges had mounted to twenty-one and the number of engineers graduated to 866. [The National Science Foundation estimated 650,000 engineers in the United States in 1954.]²⁶⁴ . . . In the period leading up to 1870 science was struggling its way with difficulty to a place of freedom and equality in the educational scheme. The scant sufferance extended to science in Eastern institutions with deeply rooted classical traditions made it necessary for applied science to seek a home with adequate resources and scope for development in independent "institutes," which did much to invest engineering education with its distinctive qualities and its traditional rigor.

Dealing with the period 1870 to 1885 the report indicates (p. 545):

This was the great formative epoch in American engineering education. The collegiate type of curriculum with its extended base of science, mathematics, languages, and social studies, though modified by the pressure of expanding engineering knowledge and technique proved its stability and became firmly established as the basic process in American education.

Continuing with its discussion of developments the report notes (p. 548):

Among the specific changes in curricula between 1885 and 1900 may be noted the distinct recovery of ground by the physical sciences, the progressive transfer of elementary mathematics from college curricula to entrance requirements, the reduction of time given to drawing and shop work as distinct subjects in favor of the engineering subjects as such, the diminished emphasis on foreign languages in consequence of the rapid growth of an indigenous engineering literature and the pressure of increasing technical specialization, the recovery of ground by English and the emergence of economics to a place of prominence among the group of social sciences.

The real significance of the changes enumerated can be better understood if we note the now most amusing statement found in the 1889 catalog of one of our institutions. It reads: "Those who desire to begin the course in Mechanical Engineering must enter the Apprentice Class. A limited number, however, may be admitted to this department in an advanced class, provided they have had sufficient experience and actual work in wood or iron in some approved shop. . ." Such preparation for entrance to college is indeed strange in view of today's technology.

Another college's catalog of 1906 states after describing the many trips to various plants as a regular part of the curriculum,

. . . But it is obvious that in the attempt to apply the principle to some concrete problem of practice, the student will most speedily gain a true comprehension of its bearing and force. He should, therefore, have as far as possible his practice in the field or in properly directed laboratories Necessarily, the nearer the field or laboratory practice is made to conform to the requirements of actual operation, the more forcible its teachings and the more valuable the experience here gained.

The Wickenden report continues on page 549:

The first decade of the century saw engineering education in America reach the climax of its popularity relative to other major divisions of higher education. As the second decade developed, agricultural education sprang into prominence and as it closed collegiate education for business was in a rapid upswing. . . . The events of the World War (1), however, served to direct attention to engineering education anew. How familiar these observations sound!

A more concrete indication of changes in engineering curricula is contained in Table I below. Except for the 1960 column, which is an estimate of today's program, the data are reproduced from page 552 of the report.

TABLE I
PRINCIPAL CATEGORY REQUIREMENTS IN ACADEMIC YEARS

Category	Year					
	1870	1885	1900	1915	1923	(1960)
Humanities	1.137	.706	.653	.560	.516	.648
Scientific	1.385	1.091	1.094	1.065	1.127	1.048
Free Electives	.026	.059	.048	.084	.151	.164
General Technology	.939	1.143	1.173	1.136	1.068	1.136
Special Technology	.509	.882	.965	1.122	1.095	.624

It is noted first that figures in each column do not add exactly to four years because certain few subjects do not properly fit into either of the categories and therefore, are omitted. This omission is even larger in 1960 because of ROTC.

It is also interesting to note the drop in humanities as well as the rise in special technology and free electives which occurred during the period 1870 to 1923. The report (p. 552) summarizes these changes as follows:

In the face of the above facts it cannot be asserted that engineering curricula have become more liberal as a result of evolution. The peak of specialization has apparently been reached and passed, there has been a gain in scientific content and emphasis, and opportunity for free election has been increased, but the prescribed humanistic content has been decreased. . . . When all reasonable allowances have been made for compensating elements not appearing on the face of the data, it still remains true that the trend of evolution up to 1915 was away from a broad educational emphasis and toward a specialized training. Since that date there has been a perceptible trend toward broader educational ideals and programs.

B. The Present

Changes in engineering curricula during the period between the Wickenden report and World War II are not of major importance. The depression years of this period left little for study and experimentation. Here and there a plea for greater liberalization of the engineering curriculum was raised. Practical subjects were emphasized because a struggling economy lacking funds for on-the-job training hired only graduates with immediate production potential.

The war years, however, created new demands. Demands for more engineers, for engineers better able to solve quickly new and changing problems, and especially for technicians capable of performing routine engineering tasks and supervising maintenance of increasingly complex material. Scientific developments during and since the war continue to make greater and greater demands upon engineering. A better understanding of scientific principles, greater use of mathematics, and a deeper appreciation of man's nature and needs all over a more mutually dependent world have placed a premium upon creative engineering, never even approached before; and this situation is getting stronger almost daily. Thus, the scope, breadth, and depth of engineering education are undergoing evolutionary change in the attempt to supply engineers capable of handling, now as in the past, the technological needs of the day.

A brief review of what may have happened to engineering education during the immediately past decade is now in order. Table II is representative

of the average engineering curriculum for each of the three years analyzed. Study groups or categories are in accordance with nomenclature popularized by the Grinter and subsequent reports.

TABLE II
CATEGORY REQUIREMENTS DURING THE FIFTIES IN PER CENT

Category	Year		
	1950	1955	1960
Mathematics	13.9	14.5	13.0
Basic Science	12.8	13.1	13.3
Engineering Science	21.0	19.8	20.9
Applied Engineering	17.2	18.2	15.1
Word Communication	6.1	6.0	4.5
Humanities	9.3	8.1	11.7
Electives	4.6	6.8	8.2
Training	2.7	3.0	2.0
Other	12.3	10.5	11.3

Certain changes are quite obvious, others, though rather important, are not. Training or skill type courses, like drafting and shop, have been reduced to a low of two per cent. Applied engineering requirements have also been reduced while humanities and elective offerings have each been noticeably increased. Changes in mathematics and the basic sciences are not evident on a percentage basis. Modifications in these categories have been principally a matter of upgrading. In practically all cases mathematics courses have become more rigorous and demanding. Chemistry and physics have also reached deeper into scientific subject matter. In addition, entrance requirements have been raised to permit commencing studies at higher levels. Thus, though only a little more time, if any, has been added more advanced material is being covered.

This evolution in the engineering curriculum is almost fully, as might be expected, in accordance with recommendations of the Grinter report. On page 12 it states:

The preceding discussion of instructional goals indicates that certain curricular areas are obviously basic to undergraduate engineering education. These areas include mathematics and the basic sciences, the engineering sciences, the application of these sciences to the analysis and synthesis of engineering systems within the student's major field, technical courses outside his major field, and humanistic and social studies.

The Evaluation Committee further proposes on page 22 the distribution contained in Table III. It should be noted that figures do not add to a whole because the Committee did not wish to specify a fully restrictive curriculum. Actually, it stated: "There will be many reasons for variations among institutions and among departments of a single institution. Experimentation (in curricula) is strongly encouraged."

TABLE III

SUMMARY OF TIME DISTRIBUTION FOR ENGINEERING CURRICULA

Category	Approximate Proportion of Curriculum
Humanities	0.20
Mathematics and basic sciences	0.25
Engineering sciences	0.25
Applied engineering--analysis, design and systems	0.25
Electives or options	0.10

C. Today's Thinking and Trends

A search of the literature between 1950 and 1960 revealed the tremendous concern of engineering educators, the engineering profession, industry and government in America's education of its scientists and, particularly, engineers. A total of over five hundred papers, pamphlets, and books have been reviewed. A majority of these (over 400) have been abstracted. All are contained under seven groupings in the Appendix to this report.

In general, strong indications exist that engineering education is a dynamic, controversial process undergoing significant changes. Its purposes are expressed in differing words, its goals are claimed many, current curricula are questioned, new ones proposed and then re-examined. Traditional subjects are being replaced, course contents modernized or at least modified, and academic years reapportioned. These things are not just paper investigations. Many institutions are experimenting, trying one idea or another, evaluating. However, opinions are definitely varied and numerous, and the emerging educational picture certainly not too clear.

A closer look at some of the opinions, recommendations, and evaluations might assist formulation of probable trends. Of course, the major publication

of the past decade is the Grinter report previously referred to. It reports upon an extensive and searching evaluation of engineering curricula and recommends some sweeping changes. Educators, industrialists, engineers, administrators and government officials were interviewed in the attempt to arrive at a broad understanding of engineering needs and a probable satisfactory method of education to meet these needs.

The category distribution contained in Table III was recommended. Mathematics and the basic sciences, physics and chemistry, constitute the foundation of the engineering education. A minimum level of required mathematics should be established with differential equations in this minimum. Physics should include some modern material, and chemistry should extend through topics in physical chemistry. The six engineering sciences--mechanics of solids, fluid mechanics, thermodynamics, transfer and rate mechanisms, electrical theory and material properties--should be in every curriculum. In some cases even the life and earth sciences have a place. The committee emphasized that the engineering sciences represent the trend in future engineering education.

Several institutions have since founded degree curricula in engineering science.

The importance of engineering analysis and creative design was strongly indicated. The place of the laboratory as a tool in helping develop an inquiring mind, the ability to organize experimentation, and skill in presentation of engineering information was stressed.

In connection with humanistic and social studies the committee stated:

If the student is to be provided with a foundation upon which he may build a career of professional stature, his education must help him to seek his fullest development as an individual. This involves stimulating his imagination, instilling a respect for learning in all its forms, and creating an awareness of the great variety of ways in which man has sought order and meaning in the universe.

As already noted (Table III) the committee recommended four-tenths of a year of electives. It stated in this connection: "The objectives of engineering education are best satisfied when each student is given a free choice of options or elective courses . . ." The changed attitude with regard to electives is well realized when it is observed that M.I.T. stated in its bulletin of 1912:⁴¹⁹ "Its courses (curricula) differ, too, from those of many others in that electives are introduced to a much lesser extent, in the belief that

better results are obtained by prescribing, . . . the principal studies which he is to pursue."

Dean S. C. Hollister pointed out early in 1952 in another ASEE report³⁶² the need for engineering curricula based upon the fundamental sciences and mathematics. It is interesting, also, to note the report's claim that architecture was "far ahead of engineering in teaching students to solve problems creatively."

Also, in 1952, Mr. Harry K. Ihrig, Vice-President in charge of Research, Allis-Chalmers Manufacturing Company, pleaded for a nonspecialized engineering curriculum.³⁶³ Prof. Hamburger of Johns Hopkins University pointed out that it is the school's duty to the profession and society to expose the student to broad fundamental knowledge in order "to uphold professional quality and achieve social maturity."³¹³

Dr. George Hawkins, Dean of Engineering at Purdue University is a little more "reasonable" in his proposal of an engineering educational program.²⁶⁷ He includes in his list of studies an appreciation of the languages of engineering, an appreciation of engineering, and acquaintance with industrial processes.

Prof. White of the University of Michigan explained his plea for a more scientific program in these words: "Education seeks to give to an average young man knowledge that will help him develop peaks of specialization when and where he needs them" ²⁰²

Dr. Hazen, Dean of Graduate Studies at the Massachusetts Institute of Technology introduces a deep idea in writing " . . . if he (student) is to be prepared for more than fairly routine responsibilities tomorrow . . . " we "must include helping the student learn how to learn, helping him to achieve skill in this learning process."¹⁰⁸

In the area of humanistic and social studies less agreement appears to exist. The Committee for the Humanistic Social Research Project²¹³ in its extensive search certainly found need for evaluation, understanding and cooperation in this area. It further completely agreed with the Grinter recommendation with regard to inclusion of study in humanities. President T. G. LeClair⁴⁰² put it this way: "If an engineer is to become a reasonably well-rounded man and not merely a highly specialized technician, he must have a

knowledge of the arts and sciences, he must be able to express himself, and he must learn how to think in general."

Professor Thomas F. Green, a young teacher, claims¹⁵⁴ that even though humanities do not make a better engineer they do awaken him to his potential as a man. Another educator, John H. Dismant argues¹⁵³ that engineers should cultivate a sensitivity for art and the humanities because the search for truth is not confined to science alone.

President Jess H. Davis of Stevens Institute is concerned²⁵⁸ about what and how educators incorporate humanities into the engineering curriculum. He concludes " . . . We need no hesitancy in trying to plan a disciplined approach even to the non-engineering subjects--with objectives clearly staked out in such a manner that we can gauge the degree of our success in meeting them. But just let's be sure that we describe those goals in detail and that we have a determination not to be deterred from attaining them." Humanities educator Weller Embler challenges²¹⁸ the notion implied in Davis' statement because humanities do not yield to a rational approach and so will not necessarily appeal to engineers who do not grasp that it is a discipline in its own right. Professor Medalia explains it all this way:¹⁷¹ "On the one hand is the drive to humanize the engineer as a way of smoothing his path to the executive suite. On the other hand is the drive to professionalize the engineer as a means of winning the respect of management, if not necessarily a place in it."

Additional suggestions, made from time to time, deal with the problem of research. For instance, Dr. Sherwood, then Dean of Engineering at M.I.T. pointed out⁴¹⁰ that university research should be such as to permit student participation. He believes students should undertake research and write theses even as undergraduates. This was the practice in many colleges long ago; it still remains in some few cases, for instance, in Ceramic Engineering at Georgia Tech. Professor Sanks of the University of Utah seconds the idea of a thesis²⁸⁹ claiming several advantages. He further believes the experimental thesis presents a greater challenge than the design or library thesis.

D. Trends

How is engineering education to do the many things required of it? The solution is not simple, the answers are many. Most schools are presently

meeting increased demands by raising entrance requirements, unifying topics and even courses, dropping minor subjects and attempting to increase effectiveness of instruction. But is this the sole answer?

As long as ten years ago, Dean Thorndike Saville urged⁴⁰⁸ a common three-year curriculum for all college students. This, followed by a slight compartmentalization in the fourth year, was to earn the student a Bachelor of Engineering degree. Additional specialization during a fifth year would then result in a designated engineering degree. The president of Penn State admits¹⁷⁹ four years may suffice to train an engineer for ordinary design and engineering pursuits but additional time is needed for higher levels of endeavor. A practicing engineer, Frederick Hotes, on the other hand, claims¹¹⁰ a need for more specialization because of increasing social and economic complexity. Thus, he envisions as long as a seven year program.

Others claim educational needs can be more efficiently satisfied by combinations of liberal arts college plus engineering college attendance. A management consultant, George Odiorne²⁸¹ thinks the two-three year plan suitable, i.e., two years at a liberal arts school and three at an engineering college. Several schools have been using this plan for a number of years now. On the other hand M.I.T. follows the three-two year scheme, i.e., three years at a liberal arts institution and two at M.I.T.²⁸⁵

Others argue the futility of extending the undergraduate period. Mr. George Barker³⁵⁰ says specialization should be left to graduate schools and employers, and the four year curriculum retained. Director of Sanitary Education, E. R. Harrington, writes in harsher terms.²²¹ He claims that if a four year program is not adequate to train engineers, a five year period will not be either. And furthermore, it may discourage engineering enrollments.

Another method of improvement proposed from the very start is that which is commonly referred to as bifurcation. The Interim Report of the Committee on Evaluation of Engineering Education³¹⁰ proposed strong consideration of educational opportunities for gifted students. It suggested three possibilities. The first suggestion considers a special curriculum "designed both in content and in method of administration to challenge adequately the exceptional group . . ." The second method is to permit "the exceptionally able student to elect his program widely" so as "to let him build out of the courses that

may be available a program that is stimulating and challenging to him." The third possibility proposed "is that of giving the student a great degree of personal freedom to study individually under general supervision and guidance in whatever way appeals to him as being most effective in his individual case." In its final report the Committee reiterated these proposals but noted that "the student who has enjoyed complete freedom under general guidance has often failed to acquire the degree of exacting mastery of basic principles that is expected."

Others have voiced similar appeals. E. A. Allcut, a Canadian educator, proposed bifurcation²⁴⁶ on the basis of mathematics: one program for industry-bound engineers, and a new mathematical program for research or academically-oriented engineers. Dean Sweigert²⁹² in seconding bifurcation, claimed it already exists to some extent through differences in choice of electives.

There appears also to have been at least a light call for a single, unified curriculum for all engineers. Dean Boelter suggested such a curriculum³³² indicating it would certainly be adequate for engineers seeking employment where on-the-job training is available. John P. Hagen in an address⁹¹ before the Newark College of Engineering pointed to the fact that the Age of Space is an age of specialization. But colleges cannot hope to graduate specialists and so must educate along fundamental lines leaving specialization to be learned on the job.

Some have proposed replacement of existing curricula by functional programs arranged according to one scheme or another. A consulting engineer, Aram Boyajian, for instance, thinks present branch curricula might be replaced by programs in manufacturing, development and application engineering.³³³ At least two prominent educators have also proposed such functional division^{345,201} only they prefer programs for research, development, production and sales.

Finally a novel, though very reasonable, proposal comes from the pen of L. V. Bewley, dean at Lehigh.¹⁴⁷ Under his system degrees would continue to be offered in the traditional branches--CE, EE, ME, etc. However, undergraduate instruction would be grouped into six service departments: Design; Power; Electrical; Chemical and Physical Properties; Processing and Manufacturing; and General Engineering and Construction. Dean Bewley claims that "probably

at least two-thirds of the actual subject matter studied by undergraduate engineering students is the same, regardless of curricula." Therefore, the plan should prove economical in manpower, facilities and space as well as prove useful in diffusing scientific and technical developments throughout curricula. Furthermore, he feels a "great flexibility inherent in the proposed organization for setting up new curricula, or combinations of old curricula, without necessitating entirely new departments."

At least two papers appear to predict, rather than just speculate, the shape engineering education is to take. Dean Elgin of Princeton predicts²⁵⁹ that by 1975 engineering science will be the basis of engineering education. Technology and art will have been abandoned while boundaries between engineering branches will have just about disappeared. Dr. McKetta of Texas also predicts¹¹⁸ that by 1984 engineering sciences will fill the undergraduate curriculum. He further thinks a two or three way division of undergraduate branches with perhaps a professional program, including internship, will constitute the engineering college.

Dr. Killian of M.I.T. and of the President's Science Advisory Committee believes¹¹⁴ curricular reforms will result in a unified undergraduate engineering curriculum along with special programs for especially gifted students.

In a survey the investigator¹³⁹ asked, "What would be your reaction to a uniform four year engineering curriculum to replace all present four year curricula . . . and resulting in a Bachelor of Science in Engineering degree?" Approximately one-tenth of ASEE members were polled. Sixty-nine per cent of them replied. Somewhat surprisingly, forty-one per cent of the academic members in the reply group favored, at least mildly, the change to a uniform curriculum. Of the nonacademic members sixty per cent favored the change. An indication that these are more than just votes can be found in the engineering science curricula which are being founded on numerous campuses. Is this the bifurcation which was strongly rejected when first proposed in 1953?

In a very recent appearance before the ASEE, Dr. Carl Borgmann of the Ford Foundation presented an appeal for bifurcation in a somewhat different way:⁹⁰

In America, we face a two-fold responsibility--the training of engineers able and willing to help other peoples develop a richer economy, and the training of engineers capable of solving the new problems of

a mature industrial civilization. . . . The man who hopes to become an engineering leader in either level of industrial civilization needs the sharpest of tools in the form of language; oral, written, pictured, and mathematical. He needs the closest familiarity with and understanding of all scientific principles; physical, biological, and social. He must know the best art of today's and yesterday's technology; the how and particularly the why of each useful application. And he must develop efficient methods of design; the integration of the pertinent parts of his knowledge into an optimum system. . . . The baccalaureate years will become more and more filled with mathematics, physics, chemistry, biology, the social sciences, languages and literature. The theory and practice of design (the unique engineering science) will more and more become the primary engineering component of the curriculum. Post-baccalaureate formal education will see a major growth and perhaps be functionally oriented with branches in engineering administration, in research and development, in design, and in technological service to emerging industrial societies.

Trends in the traditional branches of engineering--civil, mechanical, electrical--are, of course, described generally by previous discussions. It is often difficult to depict whether an author is referring to engineering education in general or a specific engineering curriculum. Nevertheless, some authors have discussed general trends as applied to a particular field.

1. Civil Engineering

Civil engineering groups appear to have been most vociferous opponents of scientifically oriented curricula. Their major argument centers around the smallness of firms which use civil engineers. Typical construction companies, municipal agencies and federal authorities cannot, in general, provide specialized on-the-job training.

Professor Whisler of Penn State writes:⁴⁶

Since the separation of the other branches of engineering from civil engineering several decades ago, the scientifics of the other fields have become predominant while in civil engineering the art of engineering has remained as a very important factor.

Thus, speaking of higher mathematics and physics, he says, " . . . for the civil engineer such courses are of little significance." He points out, however:

In contrast with other fields of engineering where the products last only a few years at most, the civil engineer builds for decades, and in some cases for centuries in the future. The highest type of intelligence is needed for such work. The quality of man needed to

supervise the construction of the San Francisco-Oakland Bay Bridge, the Hoover Dam, or the great works of the TVA certainly needs to be as high as for any other field of engineering. Yet few of these men need such advanced training in mathematics and physics as many of our leaders in education would now require. The few civil engineers in advanced design of a very special nature who do need such specialized education can best acquire it at the graduate level.

Two civil engineering educators from Stanford make similar claims.¹⁵ They further point out that few, if any, colleges are providing the specialized educational needs of the construction industry. That the outlook for the future is bleak is their prediction.

There is another side to these claims, though. Professor Day of the University of Denver speculates¹² that science is essential to the civil engineer's educational background. He thinks the construction industry is slow in recognizing that basic and engineering sciences contribute directly to its interest. Professor Wilbur of M.I.T. believes¹⁷ a balance must be sought between engineering science and art. He says there is as much danger of creating scientific as of engineering technicians, each of whom is unfit for engineering practice.

Many others in the civil engineering area have offered pleas for specialties such as sanitation, transportation, hydrology and photogrammetry.^{31,21}

2. Electrical Engineering

As early as 1951 J. D. Ryder wrote⁸⁴ of the need for training in fundamentals of electronics in place of specialization in then traditional applications. In 1953 E. E. Drees concluded⁷² four years insufficient, if more fundamentals are added as needed. Professor Schatz claimed,⁷⁶ on the other hand, that four years should suffice to acquire fundamental knowledge needed for continued learning.

Dean Terman predicts⁶⁶ the electrical engineering curriculum to consist in ten years mainly of mathematics and physical sciences.

3. Mechanical Engineering

Mechanical engineering faculties, like those of electrical schools, do not appear to have filled the education literature with numerous discussions concerning trends in their curricula. They seem instead to be moving along an

evolutionary path. Many changes in line with current demands have and are being made.

Professor Bailey of Rensselaer did argue,⁴⁴⁰ however, in 1953 that to strip the mechanical engineer's training of departmental courses is to endanger his ability to apply his knowledge. The U. S. Office of Education conducted a study of mechanical engineering curricula.⁴³⁸ It selected this branch because it represented the largest number of degrees being granted. The investigation seems to have concluded, among other things, lack of three items worthy of notice--humanities, biological sciences and ethics.

Professor Buhl, a mechanical engineer, resolved his recent discussion of engineering education this way.⁴²² He wrote:

1. Engineering education requires specific training in all phases of problem solving. This would include instruction in how to solve complete problems, the creative aspects of solution, and what questions to ask oneself in solving . . .
2. The student should be enveloped with a permissive atmosphere. He should be encouraged to solve problems in many ways. He should be free from continual evaluation while learning so that he will be free to try new methods. . . .
3. The engineering curricula should be restudied to determine if all the courses offered are truly fundamental in nature. The material should be reviewed to determine whether it is conducive to analytic and synthetic procedures.

Considering present human nature, part of this may sound too far fetched but so did Galileo's law of falling bodies back in the seventeenth century.

A representative indication of what has happened to the three curricula in the past ten years is contained in Table IV. The year 1910 is included to illustrate the long range development. As previously noted, such figures do not reveal all changes because improvement is often accomplished by changing content and otherwise raising the level of instructions. Thus, increase of allotted time in any particular category is not always necessary.

4. Architecture

Architecture has not been included in what has already been written because somehow it does not appear to belong intrinsically in the group. Architectural engineering might be considered therewith but not architecture itself.

TABLE IV

CURRICULA CHANGES IN ENGINEERING IN PER CENT

<u>Year</u>	<u>Math</u>	<u>Basic Sc.</u>	<u>Eng'g. Sc.</u>	<u>Appl. Eng'g.</u>	<u>Word Com.</u>	<u>Hum.</u>	<u>Elec- tives</u>	<u>Train- ing</u>	<u>Other</u>
Civil Engineering									
1910	12.2	15.8	11.2	22.8	4.0	6.7	0.0	27.3	0.0
1950	12.8	12.8	19.6	21.7	5.5	8.9	3.4	2.1	13.2
1955	14.4	13.9	18.7	19.1	5.2	7.8	7.8	4.4	8.7
1960	13.1	13.9	16.5	22.2	3.9	11.7	3.5	2.6	12.6
Electrical Engineering									
1910	15.7	14.0	4.5	33.0	4.0	14.3	2.1	11.4	1.0
1950	15.3	12.8	23.4	16.2	6.4	8.9	3.4	1.7	11.9
1955	15.3	12.8	22.2	17.8	6.4	8.9	3.4	1.3	11.9
1960	13.1	13.1	22.8	10.1	5.3	11.8	11.1	0.9	11.8
Mechanical Engineering									
1910	10.8	14.8	10.5	18.6	2.7	8.1	0.0	34.5	0.0
1950	13.8	12.6	20.5	13.8	6.3	10.0	7.1	4.2	11.7
1955	13.9	12.6	18.5	17.6	6.3	7.6	9.2	3.4	10.9
1960	12.9	12.9	23.4	12.9	4.3	11.6	9.9	2.6	9.5

The Georgia Tech bulletin of 1908 defined architecture⁴²¹ thus: "It is recognized that Architecture is essentially a Fine Art, and Architectural Design and the subjects related to it have, therefore, an important place in the course." The M.I.T. bulletin of the same period added:⁴²⁰ "Its successful practice demands the possession of a broad general cultivation, a liberal training in design and a thorough knowledge of the principles underlying sound construction." In 1959 the M.I.T. bulletin says:¹ "This curriculum combines selected elements of science, mathematics, humanities and basic engineering with a program of departmental studies designed to provide a generalized but thorough introduction to architecture."

Table V below, indicates changes which have taken place in the average architecture curriculum since about the start of formal education in this area and, particularly, during the past decade. As pointed out twice before,

figures alone are not all-explanatory because a lot depends upon the content and level of each course. It should also be noted that all accredited architecture curricula are of five year's duration.

TABLE V

CHANGES IN ARCHITECTURE CURRICULA

<u>Year</u>	<u>Math</u>	<u>Basic Sc.</u>	<u>Eng'g. Sc.</u>	<u>Appl. Eng'g.</u>	<u>Word Com.</u>	<u>Hum.</u>	<u>Elec- tives</u>	<u>Train- ing</u>	<u>Other</u>
1910	12.3	8.4	2.2	39.8	4.9	20.3	0.0	11.1	1.0
1950	10.8	11.2	9.5	23.3	3.9	12.9	3.4	12.9	12.1
1955	10.8	11.2	15.1	23.7	3.9	12.9	4.3	6.9	11.2
1960	18.7	11.3	12.6	29.3	3.9	13.0	5.6	3.9	1.7

The Director of Education and Research of the American Institute of Architects, Walter A. Taylor, declared, as early as 1953,⁵³⁴ architectural education problems to be: (1) a lack of appreciation of research, (2) neglect of the sciences as relating to human reactions and therefore to design, (3) difficulty of providing breadth, and (4) confusion regarding "architectural engineering." The architecture lecturer, F. L. Langhorst, claimed² only several months ago that the major weakness of today's schools is the detachment of architectural training from reality.

The confusion and controversy, which seem to have existed from the start in 1890 of architectural engineering, is well discussed in an article by Professor Wolf of Iowa State.⁵ He writes: "Over the years, architectural engineering has often been charged with being neither 'fish nor fowl.' Some architectural educators have charged that there is not enough architectural design to justify the use of the term 'architecture,' and some engineering educators have charged that there are not enough of the engineering sciences included to justify the use of the term 'engineering.'" He further suggests "the future of the architectural engineer lies in being the engineer of an architect-engineer team, on which one member or more is an architect and one or more an engineer." In closing he recommends "that architectural engineering should be considered an engineering and not an architectural discipline. Architectural engineering curricula should be strengthened in

engineering content so that they cannot be accused of being 'weak sisters' within the engineering profession."

The American Institute of Architects, apparently feeling the need for a re-evaluation of American architecture in all its phases, appointed the Commission for the Survey of Education and Registration in 1949. The extensive investigation was most complete and thorough. Its report is a record of two volumes.^{9,10}

An indication of the Institute's concern is expressed in part, at least, in statements found on pages 4 to 6 of Volume One.

Our buildings exemplify many of our most admirable traits. We boast of our towering skyscrapers, sturdy in structure, fabulously equipped, and efficient in operation. We want our sleek industrial plants, so productive, spacious, and trim. We point with pride to our comfortable suburban homes. Our best schools, hospitals, and institutions equal and perhaps surpass, the finest of any land . . . On the other side of the ledger, objective observers find too large a proportion of our buildings defective, inept, discordant, and vulgar . . . Surely the total picture, for all its exceptional highlights, leaves much to be desired. If American civilization is to be judged, at least in part by the adequacy and quality of its buildings, the balance sheet thus far is in large part unacceptable.

Dealing with its recommendations the Commission states on page 441 of the same volume.

First, the Commission affirmed its conviction that architecture is an art for all men and that the profession of architecture must be conceived as an integral part of the fabric of the nation. . . . Next, the Commission deduced from the complex nature of architecture and its all-pervading influence upon society that quality services cannot possibly be supplied by mere technicians, but that they demand practitioners who are at once outstanding professionals and enlightened citizens.

And on the next page:

In general, the Commission found that existing over-all programs of architectural education and registration are soundly conceived and on the whole, effective in terms of familiar criteria. No revolutionary change seems to be demanded. On the other hand, the Commission is convinced that what is needed throughout is intensification, systematization, refinement, and deepening. . . . While certainly rigid formulization should be avoided, it is also true that the day of laissez-faire should be definitely ended.

E. The Future of Engineering Education

To forecast the direction engineering education is to take is indeed a most risky undertaking. In these times of accelerated engineering and scientific advance, to say the least one person's calculated prediction is as good as another's. Nevertheless, the task is here and so an attempt to project trends of the past decade into, at least, the immediate future will be made. "The Next One Hundred Years"⁵³³ is recommended strongly as a scholarly extrapolation of trend curves of history and, therefore, as a fine source of what is to come.

1. Generally

There is no question but that the store of knowledge available to the engineer and necessary to his work, certainly at the upper levels, is daily increasing. He can no longer be expected to have all information at his experience-tips or even in accessible handbooks; nor can he be expected to use such information intelligently unless his understanding of the laws of nature is profound. A thorough founding in the fundamentals of the basic and engineering sciences and in the use of mathematics is the only stepping stone to efficient technique and experience in engineering.

As Dean McEachron shows¹⁶⁹ the gap between the discovery of a principle by scientists and its application in industry by engineers is rapidly closing. Michael Faraday discovered the law of electromagnetic induction in 1831. It was almost fifty years later that Thomas Alva Edison used the principle in the dynamos of a central generating station to supply electricity for his new incandescent light. The principles underlying radar were uncovered in the mid-twenties. About fifteen years later they were being used in World War II. The amplification properties of semiconductors were discovered in 1947. Less than five years later transistors were being used in telephony. The gap has been closed, for today the engineer often picks up the discovery even before the scientist has completed his work.

Thus, no doubt is left but that the engineer who is to push the frontiers of technological development forward must be exposed to an education deeper than that of his predecessor. There is also no doubt but that other engineers are needed who can help provide the material needs for a civilization geared to high standards. Because of the increased technology of modern engineering

systems and the nonlinearity considerations these bring about, both engineers must possess some understanding of specialties outside their own. Furthermore, because of the complexities of modern living and the nonlinearity of human minds, desires and wants, both engineers must possess an appreciation of matters outside the sphere of engineering. Our system must and will evolve the engineering education best designed to give us both engineers.

2. Probable Direction

There appear to be at least five directions which engineering curricula can follow in arriving at tomorrow's programs:

- (1) Liberal-engineering plan.
- (2) Bifurcation.
- (3) Functionalization.
- (4) Science-engineering plan.
- (5) Engineering science approach.

These attempts at "modernization" are singled out in the following paragraphs.

(1). The liberal-engineering plan is a five year program under which the student spends three years at a liberal arts school and then two years at an engineering school. This is the so-called three-two arrangement. Another form is the two-three plan under which two years are spent at a liberal arts school and three in engineering. In either case the liberal (humanities) education is assured and, in addition, the extra year can be used for additional work in science and technology. In the author's opinion this plan does not promise to provide the solution.

(2). The bifurcation plan was first proposed, without success, in the preliminary reports of the ASEE Evaluation Committee. Under this plan there are two curricula--the professional-scientific and the professional-general. Each of the traditional engineering departments would thus offer two programs. One program for the better students would favor engineering sciences, the other applied engineering courses. Although the introduction of more elective freedom in a sense, permits bifurcation, the author does not believe it is likely to become prominent in the near future.

(3). Functionalization calls for division of engineering curricula according to engineering function. Research, design, production, engineering administration and sales are typical of the departmental divisions and degrees which might exist under this plan. Opposition to this system would be large since it would abolish traditional branches of engineering. Therefore, this plan is also not likely to come into existence in the near future.

(4). The science-engineering proposal is a method which could easily become the scheme of engineering education of the future. Under this system service departments would be established to teach courses in the six engineering sciences--mechanics of solids, mechanics of fluids, thermodynamics, transfer and rate mechanisms, electrical theory, and materials science. These along with conventional mathematics and basic science departments, would provide probably over half the program. Communication, humanities and social sciences would comprise another portion of the curriculum. Finally the student would spend about one year in his department of specialization taking applied engineering and elective courses. Should engineering education be extended to five years--a strong possibility--a Bachelor of Engineering degree could be offered at the completion of the fundamentals program, followed by a designated degree in the branch of specialization at the end of the fifth year.

(5). The engineering-science approach, already used in several institutions, is the first step in the attempt to provide the opportunity, to at least those desiring it, for an engineering education free of specialization. The graduate of this curriculum earns usually the Bachelor of Engineering degree. In the opinion of the author more and more engineering schools are likely to introduce the program in the next few years.

It is thus the author's opinion that the course engineering education is likely to take the next few years is the inclusion of engineering science programs presented under plan 5 above. Along with this addition, traditional branch programs, of interest at this time, will change gradually as indicated in the final section of this report. It is also believed that eventually these improvements will lead into the science-engineering program of 4 above.

3. Specific Curricula

Branch curricula are not likely to leave the sphere of engineering education; nor are they likely to undergo more than evolutionary change, along lines already being pursued, in the next few years. Modifications in the direction suggested by the ASEE Evaluation Committee are being accelerated. In addition, other changes which become logical as previous ones bring about new considerations will be instituted as readied. Admission procedures, placement testing and guidance are likely to become more scientific and thus assist students and faculty to reach a higher level of attainment. If larger engineering enrollments materialize, demonstration techniques, visual aids and even closed TV instruction are likely to receive increased use. Greater emphasis on faculty recruitment and, particularly, faculty development is likely to bring about improved early instruction and methodology. Each of these is going to contribute some to the gradual raising of standards and to the completeness of the engineer's education in each area of engineering specialization. Graduates of these programs will be just as well qualified to solve the more complex problems of tomorrow as they have been in solving the less demanding problems of yesterday.

a. Architecture. It can only be predicted that the architectural curriculum is not likely to undergo any radical changes in the near future. More emphasis might be placed upon the "art" involved therein. Aesthetics, originality and imaginativeness are likely to receive more consideration in course contents. Creativity in beautification, as well as functionalization of structures, will receive strong consideration in architectural and structural design. The engineering sciences will assume a little greater part in professional practice subjects. As the A.I.A. put it "what is needed is intensification, . . . refinement and deepening."

The architectural engineering curriculum appears to need, on the other hand, much more modification. It is difficult to predict, because educators in the area themselves seem to disagree on what the curriculum should be or, really, even if it should be. However, if it is to be, it is quite certain more engineering science as well as applied engineering work will enter the program soon.

b. Civil Engineering. As noted, this area of engineering education is more in need of applied courses than other branches. Thus the greater portion of applied work in relation to the rest of the content is likely to be retained. Engineering sciences, particularly those of solids, fluids and materials, will receive intensification as well as deeper use in applied work. The net result will be somewhat less specialization at the undergraduate level. Addition of elective hours to allow greater freedom of choice is also a possibility. Civil engineering, like architecture, appears to be an area in which understanding of human nature and man's culture can be quite opportune. Therefore, humanities and social science courses could well increase slightly over the present amount.

c. Electrical Engineering. Mathematics, physics--modern as well as classical--and the engineering sciences, particularly electric theory in all its ramifications, and materials science are likely to receive even greater emphasis in the next few years. The stress is likely to be, however, a matter of deeper rather than wider scope. Experimentation, being an important link in the educational chain, is likely to receive early attention in an attempt to increase its value to the electricity student. Some changes in this area might therefore be expected in the near future. The science-engineering arrangement should prove very desirable in electrical engineering education. It may, therefore, be the first to try this plan.

d. Mechanical Engineering. Mechanical engineering education, already leaning heavily upon the engineering sciences, is likely to delve even deeper into them. Some modern and nuclear physics must soon replace some of the classical of the past. More chemistry and mathematics will be added. The science of materials needs and will receive more attention in the next few years. Humanistic studies need to be retained, at least, in the present amount. Intense studies are presently in progress concerning the area of experimental laboratories. Indications to date promise some extensive changes in this portion of the curriculum in the attempt to provide experimentation in engineering sciences in place of equipment testing, as well as

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some freedom and initiative in instrumentation. Like electrical, mechanical engineering needs that additional fifth year--the science-engineering plan should fit well here too.

Respectfully submitted:

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III. APPENDIXES, ANNOTATED BIBLIOGRAPHIES

ARCHITECTURE

CIVIL ENGINEERING

ELECTRICAL ENGINEERING

GENERAL

MECHANICAL ENGINEERING

OTHER

ADDEDUM

ARCHITECTURE

1959

1. Anonymous, Bulletin of the Massachusetts Institute of Technology, Vol. 94, No. 5, (July 1959), p. 69.
2. Langhorst, F. L., "What's Wrong with the Schools?" Prog. Arch. 40, 9 (Nov. 1959).

The major weakness of the schools is the detachment of architectural training from reality. The student's work is almost entirely done on paper, he receives a criticism and a grade, and after a summation of grades he graduates. Architectural training has taken on an air of conformism and needs to be revised.

1958

3. Anonymous, "New Kind of Architectural Education for Teachers of Architecture; Report of A.C.S.A. - A.I.A. Joint Committee." Arch. Rec. 123, 28 (Feb. 1958).

The Aspen, Colorado, Teacher Seminar was designed not to demonstrate techniques of teaching, but to bring in the elements of curriculum affecting design. A panel of speakers composed of notable men in architecture were chosen to bring subjects such as "Townscape and the Urban Core" and "Professional Practice."

4. McLaughlin, Robert W., "Trends in Architecture That Are Affecting the School's Curriculum." Arch. Forum 108, 147 (Feb. 1958).

The changes within the life of the architecture school since 1919 fall into three categories: (1) the impact of science and technology on the art of architecture, (2) the widening concept of the scope of architecture, (3) the change in the visual or expressive side of architecture.

5. Wolf, Leonard, "Architectural Engineering -- Its Place and Future." Jour. Eng. Educ. 48, 719-21 (May 1958).

Architectural engineers should be engineers, trained for the problems of building construction. The history of this branch of engineering is reviewed.

The author believes that the engineering profession should be analogous to the medical; the first degree should be an engineering B.S., with specialization reserved for a later degree.

1955

6. Anonymous, "How to Design a Good Architect; Princeton Conference." Arch. Forum 102, 140-2 (Jan. 1955).

This article is a panel discussion about the problem of educating today's architects. Some of the statements made may be summarized as follows:

1. Design should be the first basic thing a student learns.
 2. One important thing to be taught is the philosophy of responsibility.
 3. Schools should emphasize that which is hardest to get in practice, such as building law, specifications, bidding procedures, and professional ethics.
 4. The idea of a liberal education has been carried too far; things get hopelessly confused.
 5. Students should be guided toward a creative understanding of all factors which influence the result.
 6. The basic education should include economics, structural possibilities and appreciation of design.
 7. The faculty should be competent and should practice.
 8. No formal architectural curriculum should exceed six years.
7. Poulton, John F., "Coordination of Architecture, Engineering and Construction by the Project Method." Jour. Eng. Educ. 46, 383-90 (Dec. 1955).

The curriculum of architectural engineering at Virginia Polytechnic Institute is outlined. This is compared with the curricula of architecture and of building construction.

8. Sanders, Jennings B., General and Liberal Educational Content of Professional Curricula: Architecture. Pamphlet No. 116, Education Office, U. S. Department of Health, Education, and Welfare. Washington: U. S. Government Printing Office (1955). 12 pp.

The content of 38 accredited architecture curricula is summarized. The problem of liberal content is discussed in general terms, from the historical standpoint.

1954

9. Bannister, Turpin C., editor, The Architect at Mid-Century: Evolution and Achievement. Volume One of the Report of the Commission for the Survey of Education and Registration of the American Institute of Architects. New York: Reinhold Publishing Corp. (1954). 513 pp.
10. Bellamy, Francis R., editor, The Architect at Mid-Century: Conversations Across the Nation. Volume Two of the Report of the Commission for the Survey of Education and Registration of the American Institute of Architects. New York: Reinhold Publishing Corp. (1954). 260 pp.

1953

- Taylor, Walter A., "Architectural Education." Higher Education 10, 17-27 (Oct. 1953). (See No. 534, Addendum).

CIVIL ENGINEERING

1960

11. Peck, Ralph B., "The Teaching and Practice of Soil Mechanics -- A Second Comparison." Jour. Eng. Educ. 50, 309-11 (Jan. 1960).

1959

12. Day, David A., "Engineering Education and the Construction Industry: Graduates for Work in Construction." Proc. Am. Soc. Civ. Engrs. 85, (CO 1, No. 1955), 7-12 (Feb. 1959).

Science is essential to the civil engineer's educational background. The construction industry has been slow to recognize that the basic and engineering sciences contribute directly to its interest.

13. Johnson, Lee H., "Discussion of 'Importance of Emphasis in Civil Engineering Education.'" Proc. Am. Soc. Civ. Engrs. 85, (PP 1, No. 2185), 17-8 (Sept. 1959).

Civil engineering is not likely to swing completely in the direction of science. Employers expect fresh graduates to assume immediate responsibilities, using time-tested methods. Typical employers of civil engineers do not have the resources for training programs.

Mathematics and science, however, are just two of the "transferable" areas of basic knowledge. In civil engineering there are limit design, compressible fluid flow, and other topics which are basic.

The article under discussion is by L. E. Grinter (Proc. Am. Soc. Civ. Engrs. 84, (PP 1, No. 1871), 1-12 (Dec. 1958)).

14. Kiker, John E., Jr., "Discussion of 'Importance of Emphasis in Civil Engineering Education.'" Proc. Am. Soc. Civ. Engrs. 85, (PP 1, No. 2185), 16-7 (Sept. 1959).

Employers are likely to continue seeking graduates who have a knowledge of civil engineering arts and practices. The article under discussion is by L. E. Grinter (Proc. Am. Soc. Civ. Engrs. 84, (PP 1, No. 1871), 1-12 (Dec. 1958)).

15. Oglesby, C. H., and Fondahl, John W., "Engineering Education and the Construction Industry: What the Industry Should Have from the Colleges." Proc. Am. Soc. Civ. Engrs. 85, (CO 1, No. 1959), 29-47 (Feb. 1959).

The construction industry has specialized educational needs which the colleges are not meeting. Industry training programs are not the answer, chiefly because construction firms are small, and can't afford them.

A few schools -- notably Stanford, whose Master's program in Civil Engineering-Construction is outlined in this article -- are offering specialization in construction, but the outlook for the future is bleak.

16. Streeter, V. L., "Discussion of 'Importance of Emphasis in Civil Engineering.'" Proc. Am. Soc. Civ. Engrs. 85, (PP 1, No. 2042), 33-4 (May 1959).

Civil engineers are criticized for considering themselves "different" and immune from the trend toward science. Graduates who are long on skills and short on fundamentals will find themselves doing subprofessional work.

The curriculum should be stripped of all survey courses, all practice courses, many skill courses, and some design. These can be acquired by reading or during a postgraduation interval on the job.

The author strongly endorses the article under discussion (L. E. Grinter, Proc. Am. Soc. Civ. Engrs. 84, (PP 1, No. 1871), 1-12 (Dec. 1958)).

17. Wilbur, John B., "Importance of Balance in Engineering Education." Proc. Am. Soc. Civ. Engrs. 85, (PP 1, No. 2028), 15-19 (May 1959).

A balance must be sought between engineering science and art. Systematized situations with "correct" solutions are seldom found in engineering practice, and there is as much danger of creating scientific technicians as of creating engineering technicians, both unfit for engineering practice. We must "refrain from a headlong plunge into an educational pattern which ...operates, in fact, within a narrow and restrictive spectrum..."

18. Winkelman, D. W., and Maar, C. R., "Engineering Education and the Construction Industry: The Industry and the Colleges." Proc. Am. Soc. Civ. Engrs. 85, (CO 1, No. 1954), 1-5 (Feb. 1959).

The colleges are offering essentially what the construction engineer needs.

1958

19. Ackerman, Adolph J., chairman, "Report of Task Committee on Professional Education." Civ. Eng. 28, 111-23 (Feb. 1958).

The committee reports a great divergence among civil engineers' opinions concerning their profession. No unanimity is found regarding curricular content or length.

Among recommendations are the following:

1. Civil engineering curricula must maintain their separate identity.
2. The A.S.C.E. "must cooperate in the development of ...curricula applicable to the needs of the various educational institutions. Such programs call for increased emphasis on postgraduate training, extension of the time devoted to undergraduate training, ..." etc.

20. Berger, Bernard R., "Education for Sanitary Engineering Research." Jour. Eng. Educ. 48, 266-72 (Jan. 1958).

21. Davis, Harmer E., "What Basis for Education in Transportation Engineering?" Better Roads 28, 23-4, 40 (Aug. 1958).

Transportation engineering is not yet being taught in the schools. If it is to be taught, it must develop an applied-science base and a philosophy.

The revolution in transportation may make necessary this new branch of engineering. While undergraduate specialization is not likely, a graduate program in transportation engineering would include: transportation analysis, planning, design, and transportation economics and administration.

22. Grinter, L. E., "Importance of Emphasis in Civil Engineering Education." Proc. Am. Soc. Civ. Engrs. 84, (PP 1, No. 1871), 1-12 (Dec. 1958).

The case for a strongly fundamental civil engineering curriculum, as opposed to the program based upon art, is presented in detail. It is then shown that civil engineering is gradually moving in the direction recommended by the "Grinter Report" of ASEE. Sample quotations from civil engineering departments are offered as evidence.

Those branches of engineering which are now using more mathematical tools and emphasizing their relation to physics are precisely the ones who are showing spectacular growth compared to civil engineering. A heavy penalty has been paid by civil engineering for failing to stimulate progress.

23. Laubusch, Edmund J., "Education of Sanitary Engineers: An Appraisal." Jour. Eng. Educ. 48, 912-16 (June 1958).
24. Lindvall, Frederick C., "Engineering Education As It Affects Unity in the Profession." Proc. Am. Soc. Civ. Engrs. 84, (PP 1, No. 1869), 1-7 (Dec. 1958).

Civil engineering is not unique in claiming breadth of outlook, public responsibility, and economic planning, and so cannot lay claim to a distinctiveness which will allow it to retain traditional curricula. New scientific developments and mathematical tools offer as much to civil engineering as to any other branch; optimization of design, closer approach to ultimate limits, new instruments, transient load analysis, are all examples.

25. Murphy, William G., "Engineering Science in Civil Engineering." Jour. Eng. Educ. 48, 383-4 (Feb. 1958).

Civil engineering contains a strong core of engineering science, but a more deductive approach to research is now required, which will mean increasing emphasis on engineering science.

26. Rich, Linvil G., "An Integrated Curriculum in Sanitary Engineering." Jour. Eng. Educ. 48, 665-8 (April 1958).

Sanitary engineering must now cover many new pollution and sanitation areas. Therefore, the only possible approach is to integrate the work, teach the sciences and stress principles rather than practice.

27. Weidner, C. Ken., "Sputniks, Flopniks, and Engineering Education." Proc. Am. Soc. Civ. Engrs. 84, (PP 1, No. 1872), 1-11 (Dec. 1958).

In the author's experience, the engineers who are broadly trained are the ones most adaptable to new challenges. The greater the specialization, the greater the inability to meet a new situation.

1957

28. Cosens, Kenneth W., "Hydrology in the Sanitary Engineering Curriculum." Jour. Eng. Educ. 47, 421-3 (Jan. 1957).
29. Folk, S. B., "Four-Year Engineering Curricula Not Sufficient." Civ. Eng. 27, 87 (Feb. 1957).

Two years of general education, followed by three years of professional work, would elevate the capabilities and social status of engineers.

30. Ludwig, Harvey F., Laubusch, Edmund J., and Pearson, Erman A., "Sanitary Engineering Education." Proc. Am. Soc. Civ. Engrs. 83, (SA 2, No. 1218), 1-11 (April 1957).

The trend in sanitary engineering education is toward decreased specialization and increased emphasis on graduate study. More and more, sanitary engineers receive undergraduate degrees in a major branch of engineering.

31. Okun, Daniel A., "Sanitary Engineering Education: General Requirements." Proc. Am. Soc. Civ. Engrs. 83, (SA 2, No. 1219), 1-9 (April 1957).

Sanitary engineering education is best acquired by a Master's degree in civil, chemical, or mechanical engineering. The undergraduate program should be strong in engineering science.

32. Wilbur, John B., "An Excursion through Exactitude." Jour. Eng. Educ. 48, 182-7 (Dec. 1957).

Engineering education is in danger of overemphasis on science at the expense of practice. The author, a civil engineer, believes that science and engineering should be taught in parallel.

1956

33. Anonymous, "Education for Construction." Eng. News-Record 157, 160 (Oct. 11, 1956).

The Associated General Contractors of America has recommended adding electives in construction engineering and business to the civil engineering curriculum, and providing a fifth year of specialization for a Master's degree.

34. Anonymous, "Training for Construction Management." Eng. News-Record 157, 29 (July 5, 1956).

Contractors would like to see a degree awarded in the field of construction engineering. The Civil Engineering Division of ASEE met with Associated General Contractors, and together they passed a resolution to extend engineering curricula to fit graduates for the construction field, by several methods. Besides the new degree, other favored methods include: options in construction and management, graduate specialization in construction, and courses in construction management.

35. Klinger, William A., "Construction Education: Industry Leader Proposes 5-Year College Curriculum." Constructor 38, 73-5 (Jan. 1956).

Most contractors prefer civil engineering graduates trained in construction rather than design. At present, they would rather hire architectural engineers than civil.

A five-year curriculum in construction engineering is outlined in detail; typical courses from existing curricula make up the last three years of the suggested program.

Schools are listed which have "taken steps in the right direction": North Carolina State, University of Oregon, Utica College, U.C.L.A., and particularly Rensselaer Polytechnic Institute.

1955

36. Banks, H. O., "Engineering Education is Every Engineer's Business." Civ. Eng. 25, 502-3 (Aug. 1955).

A member of the A.S.C.E. Task Committee on Engineering Education registers his opinion that civil engineering is "still very much an art." Accordingly, it is dangerous to eliminate or minimize courses in engineering practice. Without them, the graduate is not prepared for his initial job.

Graduate education is desirable for some students, but civil engineering has less resources for assistance to students than other branches.

Five years is the minimum practical length for the curriculum.

37. Danforth, Herman L., "What's Wrong with Engineering Education?" Civ. Eng. 25, 267 (May 1955).

Many of the engineer's problems will disappear when graduates are men of broadened interests who can express themselves.

38. Grinter, L. E., "Education of Civil Engineers: Need for Reconsideration." Proc. Am. Soc. Civ. Engrs. 81, (No. 858), 1-8 (Dec. 1955).

The chairman of ASEE's Committee on Evaluation of Engineering Education summarizes the committees final report.

39. Moffitt, F. H., "Photogrammetry in Civil Engineering Curriculum." Photogramm. Eng. 21, 739-54 (1955).

40. Whisler, Benjamin A., "Education of Civil Engineers; Training for Civil Engineering." Proc. Am. Soc. Civ. Engrs. 81, (No. 859), 1-4 (Dec. 1955).

Civil engineering is very different from other fields. The proposals for injecting additional mathematics, solid state physics, and advanced electronics into engineering curricula are useless when applied to civil engineering. These topics, if added, would displace advanced civil engineering courses needed by the graduate.

Civil engineering must not be patterned after the education needed by the industries where research and development have become prominent.

41. Wilbur, John B., "Synthesis in Education of Engineer During Early Training Rather than Later or Not at All." Jour. Boston Soc. Civ. Engrs. 42, 30-4 (Jan. 1955).

First-year students should be introduced to comprehensive engineering problems. By emphasizing synthesis rather than analysis early in the curriculum, the student is early led to see the importance of science. The author is head of civil engineering at M.I.T.

42. Wilbur, John B., "The Paradox of Professionalism in Engineering Education." Civ. Eng. 25, 776-7 (Nov. 1955).

Professional practice is endangered by increased emphasis on engineering science in the curriculum. Judgment and imagination are the results of application, and are not encouraged by systematized thinking such as a wholly scientific approach might impart. A balance must be struck between the two outlooks.

43. Yule, Robert B., "What's Right with Engineers?" Civ. Eng. 25, 437 (July 1955).

A trained mind is not enough. The engineering graduate must have the skills he will need. The college curriculum, with its combination of the theoretical and practical, is basically sound.

1954

44. Dougherty, N. W., "Physics for the Civil Engineer." Jour. Eng. Educ. 44, 401-3 (Mar. 1954).

The engineering department should teach mechanics, fluid flow, heat and electricity to engineers, so that these topics will not be duplicated and so that physicists will be freed to teach modern physics to engineers.

45. Evans, W. S., chairman, "Report of ASCE Committee on Education Commended." Civ. Eng. 24, 109 (Feb. 1954).

The ASCE Committee on Engineering Education opposes the preliminary report of the ASEE Committee on Evaluation of Engineering Education. Particular opposition is expressed to the principle of bifurcation.

The ASCE Committee feels that separate curricula would inevitably be assigned different rank in public opinion. Other more general objectives are also expressed.

Concern is voiced regarding graduate education. Civil engineering does not have the sources of funds available to other branches.

46. Whisler, B. A., "How Should We Educate Civil Engineers?" Jour. Eng. Educ. 45, 142-6 (Oct. 1954).

The head of Penn State's Department of Civil Engineering presents the case for the traditional type of curriculum based on engineering art. Civil engineers, for the most part, enter the construction field where a knowledge of practices and materials is immediately necessary. Furthermore, many C.E.'s are hired by small companies and municipal agencies which cannot contribute to further specialized education. Only about eight per cent go into teaching or research and development where a basic science education would be profitable.

The author speaks of "broad training," but he means a broad spectrum of specialties instead of a broad scientific outlook. Differential equations and atomic physics are cited as examples of courses which the civil engineer does not require; he could make better use of business and economics courses.

1953

47. Evans, W. S., "Are We Ready to Consider a Major Change in Policy?" Jour. Eng. Educ. 43, 476-8 (April 1953).

A civil engineering educator believes that the four-year undergraduate curriculum should be devoted to basic science, and that employers should assume the responsibility for specialized training.

48. Wessman, Harold E., "What Are Contemporary Demands on the Engineering Curricula? Civil Engineering." Jour. Eng. Educ. 43, 298-302 (Jan. 1953).

Civil engineering does not need increased emphasis on science and mathematics, except for graduate study in specialized areas. A four-year curriculum does not have room for additions. Some civil engineers would profit by a fifth year of undergraduate study, but this is not necessarily recommended.

1952

49. Christensen, N. A., "Social and Political Forces Affecting Civil Engineering Education." Jour. Eng. Educ. 42, 429-31 (May 1952).

More specialists are needed for regional development on a world scale. These can best be provided by graduate study.

Civil engineering schools should push graduate work and research in order to provide the engineering scientists needed for foreign programs and national security.

1951

50. Berry, Donald S., "Educational Requirements for Traffic Engineers." Traffic Eng. 22, 69 (Nov. 1951).

An undergraduate curriculum in traffic engineering is not needed. Graduate training, undergraduate electives, and a modicum of required courses will provide sufficient training.

51. Brielmaier, A. A., "Graduate Study in Structural Engineering." Jour. Eng. Educ. 42, 33-5 (Sept. 1951).

An engineering graduate, after four years of education, cannot possibly possess broad engineering knowledge plus an acquaintance with the liberal arts, and also have special competence in one of the major branches of engineering. Graduate study is necessary to acquire this competence.

The prospective structural engineer should consider graduate study, but preferably after several years of experience.

The graduate program should contain mechanics, behavior of materials (including soils) and structures, structural analysis, structural design, and a thesis. The author suggests the following sequence of three-semester-hour courses for the M.S. degree:

Advanced Strength of Materials of Theory of Elasticity.
Elastic Stability.
Steel Design.
Concrete Design.
Soil Mechanics.
Structural Analysis: Continuous Frames.
Structural Analysis: Intermediate Trusses.
Thesis.

The doctorate program would be an extension of the above study course, with less rigid course requirements.

52. Reid, George W., and Tindal, Robert T., "On Sanitary Engineering Education." Jour. Eng. Educ. 41, 478-83 (May 1951).

A sanitary engineering program should consist of four years of study, preferably as an option of civil engineering. A fifth year, covering the expanded field, would lead to the M.S.

1950

53. Petty, Ben H., "Needs of Highway Engineering Education." Jour. Eng. Educ. 40, 393-7 (Mar. 1950).

The author considers highway engineering to be a major branch. His basis is the tremendous growth of highways and their importance to the national economy.

1949

54. Claffey, Paul J., "Most U.S. Colleges Shun Railroad Engineering." Railway Age 127, 1084-7 (Dec. 17, 1949).

Transportation and railway courses offered by schools which offer civil engineering are tabulated. Only five schools give a degree in railway engineering.

55. Cloke, P., chairman, "Principles Which Should Guide the Development of an Undergraduate Program in Engineering." Jour. Eng. Educ. 40, 52-5 (Sept. 1949).

The Committee on Undergraduate Curricula of ASEE has prepared this statement largely with reference to civil engineering. However, the statement is believed to have entirely general application.

Undergraduate engineering curricula should include: (1) general education, (2) mathematics and natural science, (3) basic engineering science, and (4) specific technological applications. The basic engineering principles are common, in large part, to all branches of engineering, and the trend seems to be toward unification of these branches.

The traditional branches are favored by the committee. Further specialization, however, is opposed.

The four-year curriculum is not opposed by the committee, but no room remains in the curriculum for the specialized courses emphasized in the past, in their opinion. Graduate school must take these courses over from the undergraduate curriculum.

Recommendations include:

1. Elimination of options in major branches of engineering.
In civil engineering, these options include aeronautical, highway, municipal, railroad, and sanitary engineering.
2. Elimination of descriptive courses.
3. That the four divisions of the curriculum (above) be given equal time.
4. That instruction in applications be concentrated in topics which the student cannot effectively secure without guidance.

ELECTRICAL ENGINEERING

1959

56. Blackwell, W. A., and H. E. Koenig, "Combined Machinery and Control Systems Laboratory." I.R.E. Trans., Education E-2, 128-34 (Sept. 1959).

The D.C. and A.C. machine laboratory is being replaced by an integrated systems laboratory at Michigan State University.

57. Canfield, Donald T., "Electrical Measurements in a Modern Electrical Engineering Curriculum." Jour. Instr. Soc. Amer. 6, 13-14, 16 (Oct. 1959).

The stock electrical measurements courses are dying because they no longer offer a challenge to the engineering student. The possibility and need of introducing an instrumentation course in its place is suggested.

58. Chenoweth, R. D., "A Realistic Program in Energy Processing." I.R.E. Trans., Education E-2, 134-8 (Sept. 1959).

Two courses are primarily discussed, from the new curriculum at Case Institute of Technology. The two courses are electromagnetic field devices I and II in the electrical engineering department. Twenty per cent of the total curriculum is devoted to humanities and social studies. It is emphasized that regardless of the curricula, success cannot be achieved without a serious, activated student body and a well-trained, dedicated faculty.

59. Hamburger, F., "Advanced Education -- Past, Present, and Future." I.R.E. Trans., Education E-2, 31-7 (April 1959).

A brief history of graduate education is presented, with emphasis on electrical engineering. Consideration is given to the non-uniformity among the various schools as to admission requirements, programs of study, degree requirements and the amount of time required. The author states the need for an effort to produce a somewhat more uniform criteria for academic rank in the electrical engineering profession.

60. Milnes, A. G., "Senior-Year Semiconductor and Electron Device Course." I.R.E. Trans., Education E-2, 6-9 (March 1959).

A course designed for senior electrical engineers is described, including outlines for lecture material, lab experiments, and testing procedures.

61. Schatz, E. R., "An Undergraduate Course in Mechanics of Materials for the Electrical Engineering Student." Jour. Eng. Educ. 49, 366-70 (Jan. 1959).

1957

62. Anonymous, "Electrical Engineering Schools Update Curricula." Electronics Bsns. Ed. 30, 23 (Nov. 10, 1957).

The aim of the new E.E. curriculum is to prevent the E.E. graduate from becoming obsolete in five years.

63. Wiley, J. Bruce, "One Answer for Two Problems? Humanistic Studies and Industry Assistance." Jour. Eng. Educ. 48, 56-8 (Oct. 1957).

Observing the dilemma of finding more room in the curriculum for humanities, while technical requirements on the graduates are increasing, the author, an electrical engineer, proposes that industry assume a share of students' educations by assuming responsibility for the "application" phase of engineering education.

1956

64. Kusho, A., and White, D. C., "Energy Conversion Highlights a New Curriculum at the Massachusetts Institute of Technology." Gen. Elec. Rev. 59, 31-4 (Nov. 1956).

A discussion of the new energy conversion curriculum changes in electrical engineering programs at M.I.T. is presented. The revised curriculum seeks to equip electrical engineers for advancing electrical technology in any industry. Three subjects make up the energy conversion sequence:

- (1) Fields, materials and components.
- (2) Electrical energy converters.
- (3) Electrical power modulators.

65. Terman, F. E., "Electrical Engineering Curricula in a Changing World." Elec. Eng. 75, 940-2 (Oct. 1956).

Five significant changes are noted to be taking place in E.E. curricula:

1. Increased emphasis is being placed on the basic sciences and fundamental engineering practices.
2. Undergraduate years are being used with greater efficiency.
3. Time devoted to college training is being extended.
4. Adult education is of growing importance.
5. Fragmentation of the broad field of electrical engineering is taking place.

Several new approaches in engineering education are currently being explored. The five-year program is being tried by several schools, but this trend is not spreading. The four-year plan is being used more effectively, and graduates are being encouraged to go on for additional graduate studies.

The unified engineering curriculum is being tested and consists of a single basic engineering program which emphasizes similarities of different fields. Disadvantages of this system are (1) the need for teachers having unusual breadth of knowledge and students with sufficient ability to carry thought readily from the general to the particular, and (2) the lack of texts designed to meet the needs of such a system.

66. Terman, F. E., "Electrical Engineers Are Going Back to Science." Proc. I.R.E. 44, 738-40 (June 1956), and 1875-6 (Dec. 1956).

The electrical engineering curriculum ten years from now will be composed of differential equations, functions of a complex variable, vector analysis, Laplace transforms, matrix theory of random process, electromagnetic theory, atomic and nuclear physics, quantum mechanics, etc., which leaves very little time for social-humanistic and traditional engineering subjects such as statics, dynamics, strength of materials, fluid mechanics, heat engines, surveying, and descriptive geometry. Thus electrical engineering is completing a return to the realm of physical science.

1955

67. Brown, G. S., "Educating Electrical Engineers to Exploit Science." Elec. Eng. 74, 110-15 (Feb. 1955).

M.I.T. has completely revised its undergraduate electrical engineering curriculum in order to:

1. Broaden and deepen the science instruction for all students.
2. Strengthen the training in electrical engineering by encouraging student initiative in the laboratory.
3. Preserve the opportunity for each student to choose his own career by eliminating the option system within the department.
4. Recognize the wide variety of interest and talent among students by allowing seniors a wide choice of electives.

M.I.T. has taken five initial steps toward the above aims:

1. Established a basic core curriculum for all E.E. majors.
2. Discontinued instruction in traditional A.C. and D.C. machinery.
3. Initiated new subjects in the core curriculum to broaden and deepen the student's understanding of the sciences of fields, materials, and energy conversion.
4. Initiated in the laboratory the doctrine of laboratory objectives toward investigation rather than instruments, methods and techniques.
5. Attempted to revitalize the field of power by initiating graduate students and staff in the broader field of energy conversion, control and utilization.

68. Lyon, John A. M., "A Professional General Curriculum in Power." Jour. Eng. Educ. 45, 700-3 (May 1955).

A curriculum in power should be strongly basic. Specialization should be kept to a minimum. The electrical engineer who majors in power should have facility with system analysis (in the broad context), network theorems, superposition symmetrical components, and transform analysis, plus other topics in electronics. He should also understand the fundamentals of nuclear processes.

At the same time, the author registers his opinion that specialized curriculum breakdowns are undesirable and unnecessary. The power graduate is first of all an electrical engineer.

69. Potter, J. G., and Olsen, L. O., "Report of Conference on Electricity and Magnetism in Engineering Education." Jour. Eng. Educ. 45, 721-6 (May 1955).

Electrical engineers should have a course in modern physics as early as possible in their curriculum. A course in the physical properties of matter (solid state) should be available as an elective for electrical engineering students.

1953

70. Arthur, G. R., and Süsskind, C., "Report on Graduate Curricula." Proc. I.R.E. 41, 1700-1 (Dec. 1953).

This is a detailed report on the 88 colleges approved in 1953 by E.C.P.D. that have E.E. graduate programs. Tabulations given include: schools reporting, faculty, degrees offered, language requirements, number of degrees awarded, graduate enrollment, financial aid, number of publications, sponsored research, and special subjects.

71. Brown, G. S., "Integration Versus Options in Electrical Engineering." Elec. Eng. 72, 595-7 (July 1953).

The power field in electrical engineering has lost much of its appeal to engineering students through the option system. M.I.T. is gradually subordinating existing machinery and power subjects and replacing them with a subject called "control and conversion of energy." This subject will explain and demonstrate to the student how engineers exploit properties of materials in a creative way in the solution of broad engineering problems.

Where there are options within a department, the student is in danger of being led into a very narrow specialty.

72. Dreese, E. E., "The Electrical Engineering Curriculum -- Present-Day Problems and Time Limitations. Curriculum Size 5." Jour. Eng. Educ. 43, 425-8 (Mar. 1953).

Four-year and five-year curricula are compared, and the author concludes that four years is no longer sufficient. The longer curriculum shows a 38% increase in technical content, 14% increase in "fundamentals," 20% increase in non-technical, and 87% more electives. Mathematics is increased by 28%, physics by 16%, mechanics by 1%, chemistry by 24%, and drawing by 25%.

73. Everitt, W. L., "What Are Contemporary Demands on Engineering Curricula? Electrical Engineering." Jour. Eng. Educ. 43, 294-7 (Jan. 1953).

A program which treats all students alike is of doubtful value. Students will not be stimulated if new ideas are labeled "specialization" and restricted to the graduate program. If engineers are to learn to solve problems, they must be introduced to the case method or its equivalent.

Three areas of study are likely to be integrated into electrical curricula in the future:

1. Biological and psychological subjects.
2. Modern physics.
3. Statistics.

74. Kloeffer, R. G., "The Electrical Engineering Curriculum -- Present-Day Problems and Time Limitations. •Mid-Century Trends in Electrical Engineering Curriculums." Jour. Eng. Educ. 43, 420-2 (Mar. 1953).

Two trends are noted: (1) introduction of options into the senior year of four-year curriculums and (2) an increase in the humanistic-social content, though only to half the amount recommended by a post-war committee (i.e., half of 24 credit hours).

75. Muller, H. N., Jr., "The Equipment Manufacturer and Power Education." Elec. Eng. 72, 295-7 (April 1953).

The power industry has doubled in capacity every decade. The usual fundamental undergraduate education should be as basic as can be designed. The employer must assume the responsibility for specialized education after the graduate has become acclimated to the industrial environment and thus in a better position to choose a field of specialization.

76. Schatz, Edward R., "The Electrical Engineering Curriculum -- Present-Day Problems and Time Limitations. Professional Education in Four Years." Jour. Eng. Educ. 43, 423-5 (Mar. 1953).

Four years is adequate for the student to acquire fundamental knowledge sufficient for continued learning.

1952

77. Ryder, J. D., "The Electronics and Communications Options -- Why?" Jour. Eng. Educ. 42, 463-6 (May 1952).

The author distinguishes between fundamental knowledge and fundamental methods in his argument for two options in the electrical engineering curriculum. Knowledge will carry the student only so far. He needs to know the methods (vector diagrams, Laplace transform, etc.) which are applied to particular problems, and the difference in methodology defines the curricular options.

78. Tarpley, H. I., "Let's Really Get Back to Fundamentals." Jour. Eng. Educ. 42, 504-6 (June 1952).

Option programs in electrical engineering have been unsuccessful, because the divisions are based largely on "hardware." The options ought to be liberalized so that the student is able to choose technical courses which will broaden his background.

79. Walker, E. A., "Specific Objectives of Electrical Engineering Curricula at the Undergraduate Level." Elec. Eng. 71, 574-8 (June 1952).

At least 20 per cent of today's curriculum is directed toward cultural development. The colleges should endeavor to instill the desire for continued self-improvement.

Three recommendations are given for undergraduate improvement:

1. Break up the types of degrees into four-year and two-year courses, four-year courses for students capable of fundamental engineering studies, and two-year courses for students of lesser ability who will become engineering assistants.
2. Provide a special curriculum for the more brilliant students.
3. Gradually change the present curriculum, allowing more time for all engineering sciences and decreasing the amount of time now used for undergraduate specialization.

80. Weber, Ernst, "Relations between Nuclear and Electrical Engineering." Jour. Eng. Educ. 42, 280-5 (Jan. 1952).

Engineers should be equipped to enter any new field of endeavor without being forced to start an entirely new professional life. This means a broad background of fundamental knowledge, and implies that nuclear engineering should not be a separate curriculum specialty.

Electrical engineering undergraduate curricula should not offer specialization in the first three years. The fourth year might provide emphasis on certain areas through elective courses, but should retain the broad outlook.

The master's program should also be very basic. Mathematics and physics should continue to be emphasized.

The doctor's program in electrical engineering similarly should include strong emphasis on mathematics and physics.

1951

81. Anderson, E. W., "Mathematics in Electrical Graduate Education." Elec. Eng. 70, 507-10 (June 1951).

The graduate student must have the proper background to study mathematics on the graduate level. The course content in graduate school should be influenced by the needs of the student, faculty, industry, alumni opinion and studies of current text and periodical literature.

82. LaPierre, W., "An Immoderate View of Undergraduate Engineering Education." Elec. Eng. 70, 299-303 (1951).

"The subject of engineering education is distressingly complicated and delightfully controversial."

The main problems of professional education are "overcrowding of curriculum, the fatigue of the students, and the recruitment of the staff."

The author recommends the reinstatement of the "daily recitation" in order to keep classes up to date on reading assignments and reduce the need for excessive lecturing. The lecture method is misapplied by many teachers who feel obligated to "read the text aloud to the class." There is a need for a "psychological conditioning" of the student toward learning. There are presently no places where engineering teachers can be taught.

83. Lewis, W. A., "Importance of Graduate Work in the Power Field." Elec. Eng. 70, 391-3 (May 1951).

The order and magnitude of complexity in the electrical power industry demand now that highly trained, competent engineers be supplied. This demand can only be met by the requirement of more than the usual four-year curriculum. A comprehensive treatment of the required topics for the power field cannot be attained in the undergraduate program alone.

There is an almost complete absence of sponsored research that is applicable to the power field. Progress in fundamental research related to the power field is almost non-existent.

Formal graduate training in adequately organized courses and more basic research are essential to meet the present and future needs of the power industry.

84. Ryder J. D., "Renaissance in Electrical Education." Elec. Eng. 70, 581-4 (July 1951).

The curriculum of 25 years ago is compared with that of today. The need for training in the fundamentals of electronics is stressed against over-specialization.

85. Swenson, George W., Jr., "Acoustics in the Electrical Engineering Curriculum." Jour. Eng. Educ. 41, 329-30 (Jan. 1951).

1950

86. Benedict, F. R., Harris, W. R., and Witzke, R. L., "Electrical Application Problems for Engineering Education." Elec. Eng. 69, 241-7 (March 1950).

The activities of the applications engineer are such that he must be highly specialized. The engineering graduate is not being prepared in the ways in which industry utilizes academic training. Senior courses involving practical problems and the use of practical problems as thesis subjects can help attain the proper end.

87. Wermath, K. W., "Trends in Education in Electrical Field." Nat. Engr. 54, 18-19 (Sept. 1950).

Trends of education for the electrical field are listed and discussed in this order:

1. The serviceman, technician, and professional engineer working as a team.
2. The trend of educational curricula being set up for all three levels in (1).
3. The trend for integration of the fields of engineering at the undergraduate level.
4. The trend of keeping the presently accepted four-year program with the fourth year being slanted toward a specialty.
5. The trend of devoting more class time to humanistic studies, with emphasis on the effective use of language.

1949

88. Kraehenbuehl, John O., "Education and Professional Engineers." Illum. Eng. 44, 596-600 (Oct. 1949).

Standards of a professional society are discussed as an introduction to the analysis of a curriculum for the illumination engineer. Some of the specific studies discussed for such a curriculum are:

1. Optics.
2. Illumination Calculations.
3. Illumination Design.
4. Sources (of Light).
5. Physiology of Vision.
6. Psychology of Vision.
7. History of Architecture.
8. Salesmanship.
9. Sales Administration.
10. Seminar (preparation and presentment of technical papers).

The entire curriculum of the illumination option at the University of Illinois is presented in a block diagram.

GENERAL

1960

89. Anonymous, "Speakers Urge Industry, Universities to Meet Needs of the 1960's." Product Eng. 31, 17 (Feb. 15, 1960).

Undergraduate courses should emphasize more strongly the basic fundamentals. Most of the practical courses of today are outmoded in ten to fifteen years.

Graduate school curricula should be up-to-date at all times. This can be aided by encouraging professors to take summer jobs in industry. Graduate courses should become more readily available to the young engineer.

90. Borgman, Carl W., "The Cloudy Crystal Ball." Paper presented at Am. Soc. Eng. Educ. meeting, Purdue University, June 22, 1960.

91. Hagen, John P., "Space and Its Challenge to Engineering." Address before the Newark College of Engineering, Newark, New Jersey, April 28, 1960.

The Age of Space is an age of specialization, but the colleges cannot hope to graduate the specialists required. The new field of space science is too broad to be mastered by any engineer. Training should be along fundamental lines, leaving specialization to be learned on the job.

92. Hazen, Harold L., "New Demands in Engineering Education." Technology Review 62, 27-9, 42 (Mar. 1960).

The dean of M.I.T.'s graduate school discusses in detail the developing concept of the engineering-science education. No curricular details are included.

The author also reviews the need for general studies and the trends regarding length of the curriculum. Graduate study is discussed in general terms.

1959

93. Alexander W. T., "Engineering Education, Experience and Expectations." Jour. Eng. Educ. 50, 10-14 (Oct. 1959).

The president of ASEE discusses engineering education. He looks forward to the day when "broad basic theory" is taught to undergraduates, leaving to advanced courses the application of appropriate segments of theory to specific fields. He points out the "strange phenomenon" of the absence of higher mathematics from higher engineering courses.

94. Anonymous, "E.C.P.D. Accreditation." Jour. Eng. Educ. 49, 625-8 (Mar. 1959).

Additional criteria, as of October, 1958, are added to the accreditation principles adopted in 1933. The acceptable curriculum is characterized, and statements are added regarding length of curriculum flexibility, and curricular breadth.

95. Anonymous, "Educators Experiment with Engineer Curricula; Offer More Science, Less Hardware." Product Eng. 30, 23-4 (Oct. 19, 1959).

The engineering science curriculum at newly founded Michigan State University -- Oakland is discussed. The first two years are given to pure science and mathematics; in the third year engineering fundamentals and more mathematics are offered. In the fourth year the student may embark on specialization in one of two areas: electronics or mechanics -- thermodynamics -- materials.

96. Anonymous, "Engineering Colleges Revamp Courses to Emphasize Science." Product Eng. 30, 19-20 (Aug. 31, 1959).

Most technical schools are emphasizing science and attempting to unify curricula. A survey of curriculum changes and experiments is presented in this article.

97. Anonymous, "Engineers Air Views on College Studies." Product Eng. 30, 39-40 (Nov. 9, 1959).

A survey of 3800 Purdue University alumni ranked these goals most important: ability to apply fundamental principles, ability to organize thought, and mastery of principles. Engineering science ranked high in the list of technical subjects.

In last place were humanistic-social studies, which were considered unimportant. About half of those responding thought that more than a year of physics was essential, a third favored more chemistry, 40 per cent favored math beyond calculus, and 25 per cent called for math beyond differential equations. Among non-technical subjects, speech and English ranked high, and business courses were considered important by two-thirds.

98. Brown, G. S., "Education for Expanding Horizons in Electric Power." Paper No. 58-PWR-12, presented at Am. Soc. Mech. Engrs. meeting, Sept. 28 - Oct. 1, 1958. 8 pp.

This is a discussion of the trend toward broader engineering education.

99. Brown, G. S., "Engineer - Scientist Coming; U.S. Scientific Education Undergoing Sweeping Changes in Philosophy and Content." Electronics 32, 53 (Nov. 20, 1959).

The engineer-scientist graduating five years from now will need intensive training in physics, field theory, structural chemistry and other disciplines. Mr. Brown says that the new curricula at M.I.T. will be geared to those who will go on for Doctor's degrees. However, B.S. recipients will be able to use their knowledge more effectively.

100. Coe, James C., "Engineering Education Now and Thirty Years Ago." Instr. Control Syst. 32, 1666 - 7 (Nov. 1959).

The author, who left teaching thirty years ago to work in industry and returned to teaching again thirty years later, compares the instructors, students, and results of yesterday's engineering schools with today's engineering schools. His conclusions are:

1. Students cover more but understand less. They are in trouble when confronted with a problem after graduation.
2. There is not enough emphasis on fundamentals.
3. Students of today are less courteous, more demanding, less thorough, less self-reliant, and less capable than the student of thirty years ago.

101. Conrad, Richard, "A social Science - Humanistic Course with a Practical Focus: Engineering Ethics." Jour. Eng. Educ. 49, 609-14 (Mar. 1959).
102. Dobrovolsky, J. S., "A Course in the History of Engineering." Jour. Eng. Educ. 49, 618-21 (Mar. 1959).
103. Dorn, John E., "Discussion of the Follow-Up Committee Report on Engineering Materials." Jour. Eng. Educ. 49, 823-5 (May 1959).
104. Galbraith, R. A., and Lakin, J. R., "Syracuse - IBM Program." I.R.E. Trans., Education E-2, 50-2 (April 1959).

Syracuse University has an off-campus type of graduate study plan that gives graduate students the opportunity to gain resident credits toward the Master's degree. There are presently three centers available at Rome, Endicott and Poughkeepsie.

105. Gilchrist, Bruce, "University Computing Courses." Jour. Eng. Educ. 49, 342-6 (Jan 1959).
106. Grinter, L. E., "A Survey of Current Changes That Are Modernizing Engineering Education." Jour. Eng. Educ. 49, 559-72 (Mar. 1959).

The author, Dean of the Graduate School at the University of Florida, summarizes the changes which have taken place since the ASEE's 1954-55 report. Schools are grouped according to the highest degree (B.S., M.S., Ph.D.) awarded in engineering; 106 schools reported.

All schools were examined for changes in curricular requirements. These are summarized below:

	<u>Mathematics</u> <u>Increased</u>	<u>Chemistry</u> <u>Increased</u>	<u>Physics</u> <u>Increased</u>
Ph.D. schools (45)	49%	11%	40%
M.S. schools (35)	34%	11%	37%
B.S. schools (26)	54%	12%	35%

In addition, other portions of the curricula were changed as follows:

	<u>Engineering Science</u> <u>Strengthened</u>	<u>Practice Courses, etc.</u> <u>Eliminated</u>	<u>Humanistic Con-</u> <u>tent Increased</u>
Ph.D. schools	87%	87%	60%
M.S. schools	69%	83%	66%
B.S. schools	54%	65%	58%

The author notes that humanistic content is approaching the level (one-fifth of curriculum) recommended by ASEE.

Also noted are "nuclear emphasis" and options in several engineering departments.

Seven pages of selected comments regarding the above trends are included.

107. Hamilton, Thomas H, and Varner, Durwood B., "The Meadow Brook Seminars on Higher Learning." Jour. Eng. Educ. 49, 553-8 (Mar. 1959).

This is a summary of ideas emanating from seminars held in connection with the founding of a new university, when six prominent educators discussed how they would organize a program in engineering science. All facets of engineering education are discussed in general terms.

The participants recognize three phases of the engineering education problem: (1) the sheer bulk of the material an engineer must cope with, (2) the great range of material to be dealt with by today's engineer, and (3) the humanistic outlook needed by the engineer.

There seems to be little agreement on what "engineering science" really consists of. Most educators agree that it must be based more solidly on other disciplines: mathematics, physics, and chemistry.

The four-year curriculum, as opposed to the five-year, is examined. The concensus is that five years is too long, and that graduate school is the answer to the problem of needed specialization.

108. Hazen, Harold L., "Reevaluation of Techniques." Jour. Eng. Educ. 50, 118-20 (Nov. 1959).

It is no longer sufficient for the engineering student merely to be taught fundamentals. The new objective must be to teach the student skill in the learning process, so that he can by himself acquire competence in fields beyond his immediate specialty.

109. Hoadley, G. B., "Course in Engineering Analysis for Superior Students." I.R.E. Trans., Education E-2, 122-4 (Sept. 1959).

A course for superior students has been offered to students of superior aptitude at the University of North Carolina. Two ideas serve as a basis for the course. One was that at some time in their undergraduate career, engineering students should meet with problems which cut across departmental lines. The other was that there are problems being faced by industry today that should be brought into the classroom.

These students are put on teams which compete with each other for solutions to current engineering problems in industry. When the course is completed, the students compare solutions with company engineers from whom came the problems.

The course has successfully achieved three purposes:

- (1) Helped the individual to solve engineering problems, not by the addition of new knowledge but by the application of basic fundamentals.
- (2) Given experience in team techniques in analysis.
- (3) Provided a significant experience for the students with engineers from industry in analysis of current engineering problems.

110. Hotes, Frederick L., "Discussion of "Sputniks, Flopniks, and Engineering Education." Proc. Am. Soc. Civ. Engrs. 85, (PP 2, No. 2185), 21-6 (Sept. 1959).

More and better specialization is foreseen as the result of social and economic complexity. There will always be a role for the "general practitioner," however, who can develop his depth by studies beyond college.

Seven years should be the minimum length of the engineering program. Then engineering education would more closely resemble medical education.

The author is replying to an article by C. Ken Weidner, (Proc. Am. Soc. Civ. Engrs. 84, (PP. 1, No. 1872), 1-11 (Dec. 1958)).

111. Ingram, S. B., "Education for the Age of Technology." Jour. Eng. Educ. 50, 159-65 (Nov. 1959).

The new trend is to provide engineering students with a foundation in mathematics and engineering science, and leave detailed application for industry to teach its engineers. The author, who is Director of Education and Training for Bell Labs, discusses education in industry.

112. Johnson, J. Stuart, "A Philosophy of Engineering Education." Jour. Eng. Educ. 49, 580-7 (Mar. 1957).

The Wayne State University dean of engineering sets forth a 12-point philosophy of engineering education. During his education the student should:

1. Develop an appreciation for the value of learning.
2. Learn to communicate his ideas.
3. Learn the basic laws and concepts.
4. Realize that engineering is both an art and a science.
5. Augment course work with laboratory practice.
6. Learn to use computers.
7. Familiarize himself with materials.
8. Learn the essentials of regulation and control.
9. Acquaint himself with modern industrial processes.
10. Learn techniques of analysis.
11. Learn methods of correlating fundamental knowledge.
12. Develop moral and human values.

113. Kezios, S. P., "Current Trends in Heat Transfer and Their Effect on Undergraduate Teaching." Jour. Eng. Educ. 49, 332-41 (Jan. 1959).

114. Killian, James R., chairman, Education for the Age of Science. Statement by the President's Science Advisory Committee. Washington: U. S. Government Printing Office (May 24, 1959). 36 pp.

Curricular improvement is a major topic of this statement. Curricular reform, long overdue, may take one or more of the following directions:

1. A unified undergraduate engineering curriculum.
2. Development of the new fields (e.g., communication theory).
3. Liberalization of course content.
4. Experimentation.
5. Special programs for especially able students.

Graduate study in engineering should be encouraged, as it "may well be the most important development in engineering education in the coming decade."

115. Kline, D. F., "Industry's Contributions and Needs in Graduate Education." I.R.E. Trans., Education E-2, 38 (April 1959).

General Electric has several programs presently in operation for the continued education of its engineering staff. The advanced technical program allows the staff to participate in company-sponsored courses of study or in the case of engineers destined for research, the honors program for graduate study. The company gives 100% tuition, book, and school expense reimbursement on a plan that could insure the Master's degree in 3 semesters. Leaves of absence, with tuition paid, are arranged for periods up to 3 years so that candidates can pursue the Doctorate on a full-time basis.

116. Lewis, Justin C., and Armsby, Henry H., "Engineering Enrollments and Degrees in E.C.P.D.-Accredited Institutions: 1958." Jour. Eng. Educ. 49, 482-98 (Feb. 1959).

Engineering enrollments for 1949-58 are tabulated. Degrees and enrollments in various branches of engineering and for individual schools are tabulated for 1958.

117. Lindvall, Frederick C., "Engineering Education As It Affects Unity in the Profession." Jour. Eng. Educ. 49, 573-9 (Mar. 1959).

The chairman of engineering at California Institute of Technology examines the forces which are tending to unify the profession and curricula.

118. McKetta, John J., "By 1984 in Engineering Education -- A Dynamic New Concept." Petrol. Ref. 38, 207-10 (Jan. 1959).

By 1984 new ideas about engineering curricula will dominate the scene. Engineering science will fill the undergraduate curriculum instead of present-day specialties.

There are several possibilities: a single undergraduate curriculum for all engineers, a two- or three-way division of undergraduate branches, and perhaps a professional program which includes internship.

119. Niebel, B. W., "Manufacturing Processes in Engineering Curricula." Jour. Eng. Educ. 49, 797-8 (May 1959).

The author argues that manufacturing processes are as basic to engineers as calculus or physics.

120. Otto, C. R., "Building Education Program in I.R.D." Paper No. 58-A-233, presented at Am. Soc. Mech Engrs. meeting, Nov. 30 - Dec. 5, 1958.
4 pp.

121. Peters, George A., and Seminara, Joseph L., "Academic Training Needs in Human Factors Engineering." Jour. Eng. Educ. 49, 799-805 (May 1959).

122. Potter, J. H., "A Doctoral Program for the Small Engineering College." Jour. Eng. Educ. 50, 46-50 (Oct. 1959).

The present-day attitude toward requirements for the Doctor's degree are reviewed by the Dean of Graduate Studies of Stevens Institute of Technology. In order that small colleges may be able to make a greater contribution to the national output of Doctor's degrees, the author proposes:

- (1) Liberalizing formal course requirements, so that students may take specialized courses at more than one location (this would overcome the major disadvantage -- small teaching staff -- of the small colleges).
- (2) External examiners for written and oral examinations.
- (3) Supervised reading courses to augment formal classroom courses.

123. Pryor, Knight, "Foreign Languages in the Humanities Program." Jour. Eng. Educ. 49, 632-3 (Mar. 1959).

124. Schiffman, Robert L., "Engineering Education and the Construction Industry: Modern Trends in Construction Engineering Education." Proc. Am. Soc. Civ. Engrs. 85, (CO 1, No. 1956) 13-7 (Feb. 1959).

Engineering education is moving toward a generalized program which will see the removal of traditional degrees. Eventually the removal of "hardware" courses will be of great advantage to the construction industry. The new engineer will be able not only to solve the old problems, but also to make advances.

Engineering specialization will be more and more reserved for graduate work. Another method of preparing engineers for construction work is the industry-sponsored training course.

The author is a civil engineering educator.

125. Schwartz, R. F., "Laboratory: Its Scope and Philosophy." I.R.E. Trans., Education E-2, 120-2 (Sept. 1959).

There should be a correlation between laboratory and classroom work. There are two views toward the subject of correlation:

- (1) There should be no time lag between the theory work and lab work since they are both a part of the process of learning.
- (2) Class work and lab work are two ways of teaching the same thing, therefore exposure to the same thing in two or more ways at suitable intervals fixes the knowledge more firmly in the mind.

The scope of laboratory is defined by several specific objectives:

- (1) It should supplement other teaching methods.
- (2) It should teach precision measurement and error evaluation.
- (3) It should provide training in the recording and reporting of data.
- (4) It should develop a certain mechanical aptitude and resourcefulness.
- (5) It should acquaint the student with techniques, equipment, manuals, and catalogs.

The question today is how to shape the technique of laboratory instruction into an efficient education vehicle.

126. Seeger, R. J., and Weber, E., "Physics in Engineering Education." Physics Today 12, 20-1 (April 1959).

127. Shomis, S. S., and Ingram, S. B., "N.Y.U. -- Bell Labs Program." I.R.E. Trans., Education E-2, 58-61 (April 1959).

New York University has established a full-time degree-granting division at the Bell Laboratories. The company gives free time to employees attending the graduate classes. About two academic years are required to complete the Master's degree.

128. Smith, James O., and Seely, Fred B., "Recommended Changes in the Undergraduate Course in Mechanics of Materials." Jour. Eng. Educ. 49, 811-7 (May 1959).

129. Spaght, Monroe E., "Industry Speaks Its Mind on Engineering Education." Chem. Eng. 66, 120, 122, 124, 126 (June 29, 1959).

Engineers do know the basic principles of their trade. Basic knowledge is the job of the university, and professional art the job of industry.

130. Stoker, W. C., and Barnes, G. C., "R.P.I. -- United Aircraft Program." I.R.E. Trans., Education E-2, 53-8 (April 1959).

A true extension school of Rensselaer Polytechnic Institute has been set up in collaboration with United Aircraft Corporation. The school is fully accredited, has a full-time resident staff, and offers resident graduate credit toward the Master's degree in metallurgy, management, electrical engineering, automatic control, aeronautical engineering, mechanical engineering, mechanics, and applied mathematics.

131. Uicker, George B., "The Place of Nuclear Science in Engineering Education." Jour. Eng. Educ. 49, 399-405 (Feb. 1959).

There is no need for an undergraduate nuclear engineering curriculum. An introductory course in existing engineering curricula, plus the infusion of nuclear and small particle theory into early course work, are called for.

132. Van Vlack, Lawrence H., "Introduction to Engineering Materials at the Underclass Level." Jour. Eng. Educ. 49, 826-30 (May 1959).

There are so many materials available it is impossible to study each individually. Therefore, principles which govern materials should be taught as a science rather than art.

133. Ver Planck, D. W., "Discussions of the Follow-Up Committee Report on Mechanics of Solids." Jour. Eng. Educ. 49, 818-22 (May 1959).

134. Walker, Eric A., "ASEE Can Meet the Challenge -- Through Reorientation." Jour. Eng. Educ. 50, 125-30 (Nov. 1959).

The president of Pennsylvania State University calls for re-examination of engineering education, with emphasis on training students to analyze and synthesize.

135. Weaver, A. B., "Physics Courses in New Arizona Engineering Curriculum." I.R.E. Trans., Education E-2, 117-20 (Sept. 1959).

The University of Arizona has revised the "common core" curriculum to the extent this requires the various engineering departments to lay the foundation for their own courses, which they have been doing for years anyway. The new physics courses are outlined. They allow a serious study of the structure of matter in the sophomore year.

136. Weber, E., "Challenges in Development of Graduate Programs." I.R.E. Trans., Education E-2, 39-43 (April 1959).

The challenges delivered to the engineering profession and engineering schools by the great world wars demonstrate the need for continuing basic research on a wide scale.

The need for a system of classifying graduate students is evident because of the many types of so-called full-time students who in actuality should be rated as part-time students. This group includes those who are attending graduate school on a half-time basis with the other half being spent in thesis research. Actually, the greatest portion of America's graduate students are part-time students.

137. Weinberg, Elliot H., "Reduction of Physics Content in the Engineering Program?" Jour. Eng. Educ. 49, 634-5 (Mar. 1959).

138. Whitman, Walter G., "Nuclear Engineering and Science Education in United States Universities." Jour. Eng. Educ. 49, 391-8 (Feb. 1959).

Nuclear engineering is not a basic field for undergraduate education but is an area where mechanical, electrical and chemical engineers, and chemists, physicists and metallurgists may specialize during graduate study. Curricula are not outlined, nor are the schools listed which offer nuclear engineering.

139. Wilson, Warren E., "Opinions on Engineering Education." Jour. Eng. Educ. 49, 773-4 (May 1959).

ASEE members were polled on two questions: (1) "What would be your reaction to a uniform four year engineering curriculum" to replace individual disciplines? and (2) "Do you think a uniform four year curriculum would be met with favor by industrial employers?"

Sixty-nine per cent replied. Opinions on question (1) were as follows:

	<u>Educators</u>	<u>Non-Educators</u>
Strong approval	9%	20%
Mild approval	32%	40%
Neutral	4%	2%
Mild objection	22%	22%
Strong objection	32%	11%

The author regards this result as "startling," when 41 per cent of academic members and 60 per cent of others favor such a radical proposal.

To the second question, answers were distributed as follows:

	<u>Educators</u>	<u>Non-Educators</u>
Yes, by most	13%	24%
Yes, by large companies	27%	30%
Half and half	26%	24%
No, by most	27%	18%
No, by all	4%	0%

To the question, what will happen to specialized curricula like sanitary engineering?, ASEE members were divided between foreseeing a decline and foreseeing no change.

The author, a small college dean of engineering, concludes that there is "a feeling that something rather radical should be done in engineering education, but not a belief that it will be done."

140. Wislecenus, George F., "Introducing Engineering Students to Fluid Mechanics." Jour. Eng. Educ. 50, 268-72 (Dec. 1959).

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141. Aldrich, B. M., "West Point for Engineers? Educator Says Yes." Machine Design 30, 31-2 (May 1, 1958).
142. Anonymous, "Engineering Education Before Congressional Committees." Jour. Eng. Educ. 49, 161-71 (Nov. 1958).

In the course of hearings before the Senate Committee on Labor and Public Welfare, March 3, 1958, Dr. F. C. Lindvall, president of ASEE, underlined the fact that American engineering education had been too narrow. Dr. Lindvall pointed out to the committee the two ways of getting more quantity into engineering education: (1) lengthen the curriculum or (2) eliminate some traditional courses in favor of basic material.

143. Anonymous, "Facilities and Opportunities for Graduate Study in Engineering." Jour. Eng. Educ. 48, 938-74 (June 1958).

At the outset of this report of the ASEE Graduate Study Commission, the background, current status, and philosophy of graduate study are examined. Curricula are not discussed.

144. Anonymous, "Objectives and Educational Programs in Nuclear Engineering Education." Jour. Eng. Educ. 48, 316-25 (Jan. 1958).

The ASEE Committee on Atomic Energy Education discusses the place of nuclear engineering in engineering education. Specific curricula are not discussed, nor is it recommended that complete programs in nuclear engineering be established.

145. Armore, Sidney J., and Armsby, Henry H., "Engineering Enrollments and Degrees in E.C.P.D.-Accredited Institutions: 1957." Jour. Eng. Educ. 48, 415-32 (Feb. 1958).

146. Barlow, H. W., "Current ROTC and Physical Education Programs in E.C.P.D.-Approved Engineering Curricula." Jour. Eng. Educ. 48, 291-303 (Jan. 1958).
147. Bewley, L. V., "Reorientation in Engineering Education." Jour. Eng. Educ. 48, 497-507 (Mar. 1958).

It is suggested that undergraduate instruction in engineering subjects be grouped into six service departments: (1) Design, (2) Power, (3) Electrical, (4) Chemical and Physical Properties, (5) Processing and Manufacturing, and (6) General Engineering and Instruction. This would avoid the extensive duplication of courses now present in separate engineering curricula.

Under this system, the same branches of engineering -- E.E., M.E., C.E., Ch.E., I.E., Mining Engineering, and Metallurgical Engineering -- would offer degrees, and there would be no unification of course work except insofar as they received the same instruction in particular courses (e.g., fluid mechanics in Ch.E., C.E., and M.E.).

There would be no separate engineering schools under the plan, only separate curricula. The author, dean of engineering at Lehigh, overlooks three disadvantages:

1. The difficulty of specializing in graduate school in the absence of a separate school of specialty.
2. The difference between curricula from college to college. For example, where mining engineering and metallurgical engineering are not offered, unit operations applies to Ch.E.'s only.
3. The fact, which the author implies, that certain degree curricula would be strongly oriented toward one department: M.E. toward power, E.E. toward electrical. In addition, only C.E.'s and M.E.'s receive significant training in mechanics.

The author recognizes the possible damage to professional pride when degree-granting schools are reduced to service departments.

After criticizing the separate schools for teaching their own brand of mathematics, the author states: "The writer inclines to the view that the time has come to relieve physics of elementary mechanics, heat, electricity and magnetism, and to place the teaching of these subjects under the corresponding engineering departments..."

148. Bishop, John A., "A 'Philosophy' Minor for Engineers." Jour. Eng. Educ. 49, 218-20 (Dec. 1958).

A professor of chemistry outlines a curriculum to broaden the humanistic outlook of engineers:

Freshman year:	English	8 hours
	Science Background	4
	History	6
Sophomore year:	Literature	6
	Science Background	4
	Ethics	3
	Fine Arts	3

Junior year:	Psychology	3 hours
	Political Science	6
	Fine Arts	3
	Economics	3
Senior year:	Philosophy	6

The author believes that no sacrifice in engineering class hours would be necessary with this curriculum.

It is the author's belief that, in addition to broadening the student's outlook, this curriculum would help the student in dealing with "non-engineering" people.

149. Boulton, B. C., "Case for Two-Year Graduate Degree." I.R.E. Trans., Education E-1, 10-12 (March 1958).

The two-year graduate "professional degree" is deemed necessary by some sections of industry because the majority of today's one-year Master's graduates do not have enough mathematics, mechanics, thermodynamics, etc., to solve the complex problems they are confronted with. It is suggested that a two-year graduate degree would entice students who recognize the value of higher education but who are not willing to spend the time necessary to win a Ph.D.

150. Bray, Oscar S., "Engineering Sciences in the Ideal Curriculum." Jour. Eng. Educ. 48, 381-2 (Feb. 1958).

Engineering science, basic science and mathematics should constitute 50 per cent of engineering undergraduate curriculum. The average at present is nearer 40 per cent.

- Brown, Bonner and Weir, The Next One Hundred Years. New York: The Viking Press (1958). (See No. 533, Addendum.)

151. Chambers, C. C., and Branigan, G. F., "E.C.P.D. Accreditation of Engineering Curricula." Elec. Eng. 77, 686-8 (Aug. 1958).

The general objective of E.C.P.D. is the development of engineering as a profession. Recognition of engineering legally as a profession has been accelerated by the activities of E.C.P.D. and its work in accreditation of engineering schools.

152. Creamer, W. J., "Engineering Education Yesterday, Today, and Tomorrow." Elec. Eng. 77, 929-32 (Oct. 1958).

The relation of industry to engineering education cannot be ignored, because the primary purpose of the school is to satisfy the needs of industry. The opinion of the author is that "the intelligence of the average student of today is higher than 40 years ago, but the students have a tendency to use their intelligence less. The electrical engineering curriculum is much more demanding today, but the best of the graduates of today are of much finer quality than 40 years ago. The engineering college must cease teaching technicians, and concentrate on preparing young men for leadership in research, development and management."

153. Dismant, John H., "The Scientist and the Humanities People." Jour. Eng. Educ. 49, 157-8 (Nov. 1958).

The author, a Mining and Metallurgy educator, argues that engineers should cultivate a sensitivity for art and the humanities, since the search for truth is not confined to science alone. He proposes no curricular revisions, but implies that an avocational interest is desirable.

154. Green, Thomas F., "A Humanities Teacher Looks at Engineering Education." Jour. Eng. Educ. 48, 573-6 (Mar. 1958).

The reasons for studying humanities are explored. It is pointed out that the humanities, because they call into question the very values on which engineering rests, can exert a powerful influence on students unprepared for analysis on these terms. Humanities do not make better engineers. Instead, they awaken the engineer to his potential as a man.

155. Hall, N. A., "Engineering Science, the Core of Engineering Training." Mech. Eng. 80, 44 (July 1958).

There is a constant need for introducing new developments of engineering into the curriculum.

156. Harnwell, Gaylord P., "Instrument Education in the Space Age." Jour. Instr. Soc. Amer. 5, 16-17 (Dec. 1958).

The curricular requirements of the instrument engineer are solid and fluid mechanics, thermodynamics, statistical or rate processes, solid state technology, electrical or electronic science, economics, sociology, and the humanities. It is the author's opinion that the instrument engineer is unique and this uniqueness requires that he be taught by scientists rather than engineers.

157. Haynes, Fred B., "Can Industry Assist in Advanced Engineering Education?" Jour. Eng. Educ. 48, 887-90 (June 1958).

The cooperative Master's degree program operated by Martin Aircraft and Drexel Institute of Technology is discussed. Degrees are offered in E.E., M.E., physics and aero-engineering.

158. Hill, W. Scott, "Engineering Problems Ahead and Their Meaning for College Educators." Jour. Eng. Educ. 49, 244-6 (Dec. 1958).

The chief of engineering recruiting for General Electric adds his voice to the plea for engineers trained in fundamentals. A few of the major problems which industry will be working on in the future are outlined.

159. Hodgins, J. W., "Aspects of Modern Engineering Education." Paper No. 539, presented at Soc. Automotive Engrs. meeting (Can. Section), Nov. 20, 1957 (1958). 7pp.

160. Holstein, Edwin J., "Socio-Humanistic Studies for American Engineers." Jour. Higher Educ. 29, 257-60, 291 (May 1958).

The author shows that the trend of the last ninety years is away from socio-humanistic studies in the engineering curriculum. The most prominent attitudes behind this trend are reviewed.

161. Holzman, D. L., "G. E. Review Readers Urge Social Studies for Engineering Students." Gen. Elec. Rev. 61, 31-2 (Nov. 1958).

The author attempts to explode the theory that scientists and engineers are "anti-humanists." A cross-section sample was taken from professional engineers concerning what have been the most valuable subjects in contributing to their advance and success in the profession. The three most often mentioned were mathematics, electrical theory, and English, in that order. English consistently rated high with all participants. Forty-six per cent of the participating engineers were electrical engineers.

162. Honnell, P. M., "Electrical Engineering Education for the Future." Elec. Eng. 77, 940-3 (Oct. 1958).

Among the characteristics of a great technological institute will be:

1. A demand for scholarly attainments from the students as well as the faculty.
2. Good graduate sections as well as undergraduate divisions.
3. A balance between "strong, independent, scholarly departments in science, humanities, and engineering.
4. Research as an integral part of under-graduate as well as graduate education.
5. Academic leaders speaking out on objectives, principles, and methods for obtaining successful engineering education.

163. Killian, James R., Jr., and Rhodes, Fred H., "What's Wrong with Engineering Education." Chem. Eng. 65, 173-4, 176 (April 7, 1958).

Engineering education is behind the times. A more fundamental education is needed, and opportunities for graduate study should be extended.

164. Landis, Fred, "An Engineering Teacher Looks at the Humanities Program." Jour. Eng. Educ. 48, 568-72 (Mar. 1958).

A revised humanities program is suggested by a mechanical engineer, with the purpose of ensuring that the recommendations of the ASEE are met. Course content is discussed in detail. The following is a summary of suggested content:

Freshman English (rhetoric, composition)	6 credits
Western Civilization Survey	6
Economics	3
American History or Political Science	3
Elective	9

165. Lewis, David W., "A Plan for Integrating Courses." Jour. Eng. Educ. 48, 559-61 (Mar. 1958).

A scale model of an industrial enterprise (e.g., an aluminum plant) is suggested as the unifying influence in an engineering curriculum. Students in all branches of engineering would be referred throughout their education to the model, so that the significance of course material may be emphasized, and so that all engineers may see the interrelation between their various disciplines. The author is a mechanical engineer.

166. Lindvall, Frederick C., "Engineering Education; Retrospect and Prospect." Electronic Ind. 17, 88-9 (Sept. 1958).

With the great educational needs of the electronic, information theories, jet propulsion and structural engineering fields came a great demand on the undergraduate engineer's curriculum. Changes in curricula are necessary in order for the colleges to supply the demand, but dropping some of the older subjects has not been easy. Today's emphasis is on creative thinking, the new, the undiscovered ideas, devices and systems. A broad fundamental engineering education is a must.

167. Lindvall, Frederick C., "Postgraduate Engineering Education in Industry and the Community." Jour. Eng. Educ. 48, 701-7, 721 (May 1958).

Many aspects of postgraduate engineering training are discussed. The problems of industrial scholarships for graduate students receive particular attention.

168. Lindvall, Frederick C., "Remarks on Integration of Mathematics, Physics, and Mechanics." Jour. Eng. Educ. 48, 732 (May 1958).

Course content should overlap; there is no consideration given to combining courses.

169. McEachron, K. B., "Engineering Education is Closing the Gap." Case Alumnus, 18, (April 1958).

170. McLean, W. G., and Larsen, K. D., "Integration of Basic Science Courses at Lafayette College." Jour. Eng. Educ. 48, 733-6 (May 1958).

Courses were investigated for their overlap with the content of elementary physics. Then these topics were deleted from physics or minimized. The author discusses the philosophy of teaching physics and mathematics in the engineering departments, and concludes that it is undesirable.

171. Medalia, Nahum Z., "Professional and Managerial Goals in Engineering Education: A Sociologist's Comment." Jour. Eng. Educ. 49, 237-40 (Dec. 1958).

Two main forces are contending for dominance in the engineering curriculum: (1) the humanizing trend and (2) the professionalizing trend. The conflict is causing confusion, which may account for the dissatisfaction that practicing engineers feel.

172. Mikhail, S. L., "Our Greatest Need in Science and Engineering Education." Jour. Eng. Educ. 49, 241-3 (Dec. 1958).

Our greatest need is philosophical roots. No specific curricular applications are mentioned.

173. Nordby, Gene M., and Fairman, Robert N., "Engineering Sciences -- Still Another Look." Jour. Eng. Educ. 48, 527-9 (Mar. 1958).

Two members of the National Science Foundation briefly summarize the growth of the engineering science concept.

174. Olmstead, Sterling P., "General Education and the Law of Increasing Entropy." Jour. Eng. Educ. 48, 545-50 (Mar. 1958).

If humanities are to be useful to the technical graduate, they must consist of material which will provide him "continuing nourishment." Otherwise they will be lost to him. No specific suggestions are offered.

175. Rettaliata, J. T., "Industry and Education." Western Elec. Engr. 2, 3-6 (April 1958).

It is becoming more and more the responsibility of industry to provide training in the arts and skills and special technology for engineering personnel so that they can continue to be well informed on current technological advances and developments. Industry has recognized the value of providing means for its engineers to pursue graduate studies.

Specialization is vanishing from the undergraduate programs of leading colleges and is being placed into the graduate area. The effect of this shift is an approach to the unified curriculum in which all undergraduate students receive practically the same course of study. The increasing complexity of technology has tended to make the Bachelor's degree the minimum standard for admission to the engineering profession. More emphasis is being placed on social-humanistic studies so that the engineer might be more competent in his performance as a leader and citizen.

176. Ryder, J. D., "An Experiment in the Reduction of Physics Content." Jour. Eng. Educ. 49, 118-21 (Nov. 1958).

177. Terman, Frederick E., "Observations on Engineering Education." Aero/Space Eng. 17, 48-9 (Dec. 1958).

The four-year program can no longer supply the education necessary for today's technology. Industry is beginning to depend more on graduates of higher levels than the B.S. An enlarged program, in which governmental and industrial support through fellowships and research aid is vital, is cited.

178. Tobin, Austin J., "Engineering and Management Decisions in the Port of New York Authority." Jour. Eng. Educ. 48, 530-7 (Mar. 1958).

The director of the Port Authority discusses what is required of engineers in his organization: breadth of view, humanistic outlook, questioning attitude.

179. Walker, Eric A., "Next Redesign Project? Engineering Curricula." Product Eng. 29, 35-6 (Nov. 17, 1958).

The president of Pennsylvania State University, in an address, criticizes the four-year engineering curriculum as inadequate for graduate study. The four-year program adequately trains the engineer for design and engineering work, but not for higher skills.

180. Weber, Ernest, chairman, "Report on the Engineering Sciences 1956-1958." Jour. Eng. Educ. 49, 33-91 (Oct. 1958).

The ASEE Follow-Up Committee on Evaluation of Engineering Education reports its ideas on the appropriate scope of the six engineering sciences -- mechanics of solids, mechanics of fluids, transfer and rate processes, thermodynamics, electrical sciences, and nature and properties of materials -- plus the topic of engineering analysis and design.

The committee expresses its belief that "...it appears important that the basic concepts and principles which...make up engineering science, be taught in some form, in some course, at some time, to each engineering student..."

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181. Calvert, J. F., "Impact of New Engineering Concepts on Engineering Education." Elec. Eng. 76, 1041-4 (Dec. 1957).

The old methods of computation used in engineering colleges today should be revised to include new methods such as automatic calculation by computers. Tomorrow's engineers need to be familiar with the new concepts and new equipment associated with information, control and computational theory.

182. Davis, W. Kenneth, "Not 'Nuclear' But 'Modern'." Chem. Eng. News. 35, 36 (April 1, 1957).

There is no need for a new field of "nuclear engineering." A modern engineer, however, is needed who is better versed in chemistry, physics, and mathematics.

183. Drucker, D. C., "Integration of Subject Matter at Brown University." Jour. Eng. Educ. 48, 243-7 (Dec. 1957).

At Brown all engineers -- aeronautical, civil, electrical, and mechanical -- take an integrated curriculum in their first three years.

184. English, J. M., "Report of the Ninth Annual College-Industry Conference." Jour. Eng. Educ. 47, 613 (Mar. 1957).

Recommendations of the conference included:

1. Emphasis on basic sciences in curricula.
2. Students should be introduced to the requirements for teamwork.

185. Ermene, J. J., "Liberal Arts -- Engineering Courses in the United States." Jour. Eng. Educ. 47, 670-4 (April 1957).

The stratified liberal arts - engineering concept, whereby prospective engineering students perform all their work in humanities, pure sciences, and most mathematics in liberal arts curricula before entering engineering school, is discussed from a historical viewpoint. These stratified courses are usually five years in length.

The off-campus method of obtaining liberal arts preparation is discussed, and schools are listed which have liberal arts affiliates.

186. Frank, Nathaniel H., "The Task Ahead for the Physics Division." Jour. Eng. Educ. 48, 22-4 (Oct. 1957).

The author discusses implications of the increasing demand for physics in engineering curricula.

187. Graham, John W., Jr., "What Some of the Colleges are Doing about Ethics." Jour. Eng. Educ. 48, 179-81 (Dec. 1957).

This is a survey of what is being offered in ethics courses for engineers.

188. Harris, Charles O., "Integration of Subject Matter at Michigan State University." Jour. Eng. Educ. 48, 241-2 (Dec. 1957).

Changes in mechanical and electrical engineering curricula are discussed.

189. Heacock, Frank A., "The Graphic Approach to Engineering Education." Jour. Eng. Educ. 47, 690-4 (April 1957).

The strength of the graphic approach is that the student can learn engineering more easily; "the eye is the open door to the mind." Graphs and drawings have a place throughout the engineering curriculum.

190. Kazda, Louis F., "Automatic Control Systems -- The Unification of Engineering." Jour. Eng. Educ. 47, 415-20 (Jan. 1957).

An undergraduate engineering student can learn the basic concepts of automatic control systems in a semester, but two semesters of graduate courses are required before he can design systems. Every undergraduate engineer should have one such course.

191. McCallum, W. W., "Educating Industrial Managers for Tomorrow." Jour. Eng. Educ. 47, 450-5 (Jan. 1957).

A manager argues for training engineers in the overall phases of management. Engineers need training in human relations, communication skills, and economics.

192. McFarlin, Robert J., "The Teaching of 'Engineering Philosophy'." Jour. Eng. Educ. 47, 776-8 (May 1957).

A freshman and sophomore course series on engineering philosophy and ethics is described as a broadening influence.

193. Mills, Blake D., Jr., "Some Aspects of Einstein's Relativity in Engineering Education." Jour. Eng. Educ. 47, 675-82 (April 1957).

In order to induce students toward thinking along genuinely fundamental lines, some elements of relativity could be introduced into instruction. The principal example discussed is the dynamics of moving bodies, but several other topics are mentioned.

194. Newman, E. S., "What Effect Have Recent Inventions and Discoveries Had on Engineering Curriculums and Education? Deans of Engineering Meet at Purdue." Mech. Eng. 79, 1079-80 (Nov. 1957).

Two trends seem to be forming: integration of subject matter and development of the bifurcated curriculum. The bifurcation would consist of a curriculum for science-oriented students and a curriculum for production-sales-management training.

195. Ostle, Bernard, "Statistics in Engineering." Jour. Eng. Educ. 47, 410-14 (Jan. 1957).

Every undergraduate engineer should have at least one basic course in statistics.

196. Rettaliata, John T., "Four Years Plus for Engineers Predicted by College President." Machine Design 29, 5 (Sept. 5, 1957).

Remarks of the author are summarized. The author predicts changes in line with recommendations of the ASEE "Grinter Report."

197. Ryder, J. D., "Engineering Education: View Ahead." Proc. I.R.E. 45, 1459-62 (Nov. 1957).

Engineering education is taught in two parts:

- (1) Science, which is the duty of the college.
- (2) The arts, which may be best taught in industry.

The arts and sciences referred to here are best explained by the author's definition of engineering: "Engineering is the science and art concerned with the utilization of materials, energy, and men."

198. Sherborne, John E., "Today's Petroleum Engineering Graduate -- Will He Meet Tomorrow's Challenge?" Jour. Petrol. Tech. 9, 15-18 (Aug. 1957).

Current trends in engineering education are reviewed. The increasing importance of science, the need for humanities, and the pressure for a more lengthy education are among the curricular problems discussed.

199. Smith, Lloyd P., "Objectives, Curricula, and Results of the Cornell Engineering Physics Program." Jour. Eng. Educ. 47, 401-9 (Jan. 1957).

After a decade of teaching the five-year curriculum in engineering physics, the former director examines the results. The curriculum is increasingly popular with students, but no other schools are mentioned as offering this degree.

The curriculum, containing four full years of mathematics, five of physics, with the rest divided among applied science, practice, and humanities, is examined in detail. There is a nuclear technology option.

Although an advanced degree is not offered, about half the graduates go on to further work in other disciplines.

200. Vail, Charles R., "Graduate Programs as Preparation for Engineering Teaching." Jour. Eng. Educ. 47, 585-8 (Mar. 1957).

Graduate programs should be flexible enough that the student training for teaching is able to acquire some elements of pedagogy.

201. Walker, Eric A., "Research and Engineering Education." Jour. Eng. Educ. 48, 70-80 (Nov. 1957).

Among other suggestions, the president of Pennsylvania State University suggests that engineering curricula be revised so that research engineers, development engineers, production engineers, etc., are the product, rather than the traditional branches. He also urges emphasis of basic knowledge.

202. White, Robert R., "The Engineer and the Spectrum of Knowledge." Chem. Eng. Prog. 53, 19-20, 22-4, 26 (May 1957).

"Education seeks to give to an average young man knowledge that will help him develop peaks of specialization when and where he needs them..." Engineering science is a force which is distributing the emphasis in education more broadly over the spectrum of knowledge. The effect is particularly great in mathematics, now that it is recognized that engineers need to use more numerical and stochastic methods.

The only argument for undergraduate specialization is that students should know what specialization is.

Graduate work should include more and broader mathematics, well into its philosophical aspects, and heavy emphasis on social sciences. "Expeditions" of two or three years into research should be virtually omitted. Problems of a comprehensive nature, prepared with the cooperation of industrial people, would preserve the values of the traditional dissertation.

203. Zant, James H., "Modifications in Freshman Mathematics for Engineers." Jour. Eng. Educ. 47, 739-44 (May 1957).

Engineers should be introduced to many of the topics of modern mathematics: logic, set theory, groups, matrices, etc. Recommendations concerning other modifications include the following:

1. Start the student far along, in analytics or calculus.
2. Modernize course content.
3. Integrate subject matter, to make plain the unity of mathematics.
4. Offer a choice of advanced courses, in line with needs of different branches of engineering.
5. Infuse more mathematics into engineering courses.

204. Zetler, Robert L., "What's Base in a Basic Curriculum?" Jour. Eng. Educ. 48, 96-101 (Nov. 1957).

A professor of English outlines basic requirements of humanities in engineering curricula.

205. Zizicas, George A., "Proposed Reorganization of Graduate Courses in the Mechanics of Solids." Jour. Eng. Educ. 47, 839-42 (June 1957).

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206. Adler, Richard B., "Science and Engineering Education." Jour. Eng. Educ. 47, 121-8 (Oct. 1956).

An electrical engineer proposes a strong infusion of science into engineering curricula. An undergraduate program would include:

Mathematics	4 years
Physics	4
Other Sciences	2
Humanities	4
Science Applications	4

He comments that the difference between a scientist and an engineer, at the undergraduate level, is largely the direction of their interests: either the unanswered questions of nature, or the consequences of the already-answered question.

207. Anonymous, "Dartmouth Adopts New Program." Midwest Engr. 9, 13 (Sept. 1956).

Dartmouth's engineering science curriculum is described in general terms.

208. Anonymous, "M. J. Kelly Urges Five-Year Engineering Course at ASEE Meeting." Mech. Eng. 78, 688, 690 (July 1956).

Mervin J. Kelly, president of Bell Telephone Laboratories, believes the four-year curriculum does not give sufficient training.

209. Anonymous, "Purdue Engineers State Need for Social Studies, English." Machine Design 28, 14 (April 19, 1956).

A survey reveals that Purdue graduates believe that social sciences are the greatest curricular need. English was second choice. Nine other subjects, all technical, were mentioned.

210. Anonymous, "Report of the Prototype Chicago Industry - Education Conference on the ASEE Evaluation Report." Jour. Eng. Educ. 46, 818-22 (May 1956).

Industrial leaders endorsed the findings of the ASEE committee in its "Grinter Report" on the evaluation of engineering education. In particular, industry leaders approved of the basic science approach to engineering education, leaving the training in engineering arts to industry itself.

A prominent attitude of industrial leaders is that engineers need to learn to communicate. Humanities, on the other hand, may weaken the curriculum if they are overemphasized.

211. Anonymous, "Report on Evaluation of Engineering Education." Product Eng. 27, 354, 357, 359 (Jan. 1956).

The "Grinter Report" of ASEE is presented in abstract.

212. Armore, Sidney J., and Armsby, Henry H., "Engineering Enrollments and Degrees in E.C.P.D.-Accredited Institutions: 1956." Jour. Eng. Educ. 47, 619-36 (Mar. 1956).

213. Burdell, Edwin S., chairman, "General Education in Engineering. Report of the Committee for the Humanistic-Social Research Project." Jour. Eng. Educ. 46, 619-750 (April 1956).

The committee recommends the following:

Philosophy:

1. Engineering and arts faculties must formulate the program jointly.
2. Humanities and social sciences are disciplines in their own right.
3. Engineering must be viewed as a profession with social responsibilities.

Content:

1. Humanistic-social studies are distinct from business courses.
2. The program must be both humane and social.
3. Experimentation should be encouraged.

Arrangement:

1. The recommendation of the "Hammond Report" (for a four-year series).
2. Interrelationships should be emphasized.
3. Elective work should be carefully controlled.
4. The engineering school should join with other professional schools to establish a common program.

Time:

1. The 20%-of-curriculum figure is reaffirmed.
2. Time may be saved by exploiting vertical sequence and interdisciplinary approach.
3. Time may be saved by integrating scientific and technical work.
4. ROTC should not be substituted in the program.

The basic findings of the committee may be summarized as follows:

1. Educators agree that students would profit from fuller acquaintance with general studies.
2. Educators fear that time will be lost from technical material.
3. Some schools, by careful planning, have improved both humanistic and technical training.

The report includes a large number of excerpts from field reports, eleven representative humanistic-social sequences, descriptions of several courses of special interest, and sixteen sample curricula (from several branches of engineering) which have successfully introduced a humanistic-social program.

214. Burdell, Edwin S., "Presenting General Education in Engineering. Report of the Humanistic-Social Project." Jour. Eng. Educ. 47, 103-5 (Oct. 1956).

Humanistic-social programs for engineers are successful when there is strong administrative support. Professional competence need not be sacrificed by humanistic programs, if technical courses are regrouped and if industry and the graduate schools assume responsibility for specialized instruction.

215. Chang, Sheldon S. L., "Suggestions on How to Teach 'Engineering Sciences'." Jour. Eng. Educ. 46, 456-7 (Jan. 1956).

It is suggested that five of the six engineering sciences (excepting only electrical science) be taught in a single integrated course.

216. Davis, Jess H., "The Need for More 'Know Why'." Jour. Eng. Educ. 46, 790-2 (May 1956).

217. Dymont, S. T., "Engineering Education." Paper presented at Soc. Automotive Engrs. meeting, Jan. 16, 1956. Abstract in Jour. Soc. Automotive Engrs. 64, 63-4 (Aug. 1956).

Industry wants engineers who are capable of becoming managers. Specialized training does not produce them; broad, fundamental training prepares the engineer for the varied situations he will encounter. Industry must provide the specialized training.

218. Embler, Weller, "Another Look at General Studies." Jour. Eng. Educ. 46, 551-4 (Mar. 1956).

The author challenges the notion that engineers will necessarily profit from additional humanities. Humanities, being a field of endeavor which does not yield to a rational approach, will not necessarily appeal to engineers who do not grasp that it is a discipline in its own right. The answer is motivation, not additional work.

219. Everitt, W. L., "The Impact of Modern Physics on Engineering Education." Jour. Eng. Educ. 47, 113-20 (Oct. 1956).

The dean of engineering of the University of Illinois reviews the effect of modern physics. His principal concern is with viewpoints, and he does not explicitly mention curricula.

220. Flood, Merrill M., "Management Science and Operations Research." Jour. Eng. Educ. 47, 106-12 (Oct. 1956).

Several universities now offer advanced degrees in the field of management science or operations research. The Columbia University doctoral program of the Department of Industrial and Management Engineering is described.

221. Harrington, E. R., "Engineering Education -- Four-Year Course Favored." Civ. Eng. 26, 365 (June 1956).

If the four-year curriculum is not adequate for training engineers, the five-year program is likely to be inadequate also; the graduate can never be completely readied for practice. The five-year program also presents the danger of discouraging enrollments.

222. Hazen, Harold L., chairman, "Additional Criteria for Accreditation of Engineering Curricula." Jour. Eng. Educ. 46, 816-7 (May 1956).

The E.C.P.D. in October, 1955, approved the following supplemental criteria for accreditation:

1. All curricula shall contain at least one year of mathematics and basic science.
2. All curricula shall contain at least one year of engineering science.
3. One-half year shall be devoted to engineering analysis, design and engineering systems.
4. The curriculum shall be designed as an integrated sequential study.
5. One-half to one year of the curriculum shall be the minimum for humanistic and social studies.

223. Hutchisson, Elmer, chairman, "The Role of Physics in Engineering Education." Jour. Eng. Educ. 46, 592-606 (Mar. 1956).

The goals for physics in engineering education are set forth, and seven general recommendations are made. No specific recommendations regarding curricula are made.

224. Katz, Donald, L., "A Professional Program for Advanced Study in Engineering." Jour. Eng. Educ. 47, 248-54 (Nov. 1956).

The demands upon professional engineers are not entirely consistent with the Ph.D. program required by most engineering schools. A single type of program does not prepare engineers for the full range of industry's needs.

A program is suggested which would extend three years beyond the B.S. degree. It would include two full years of class study, and a year spent in solving problems, including qualifying examinations similar to those now used.

A sample curriculum for chemical engineers is outlined. Typical problems for the third-year student are set forth.

225. Kerekes, Frank, "The English Program as Engineering Teachers View It." Jour. Eng. Educ. 46, 427-33 (Jan. 1956).

Because 60 per cent of all practicing engineers find good English "of considerable value" or even necessary, and because writing consumes up to 25 per cent of engineers' time, it is desirable to develop a realistic English program for the curriculum. The following recommendations are offered:

1. Emphasize communications in English courses.
2. Contemporize the humanities.
3. Extend writing requirements beyond the freshman year.
4. Offer a course in report preparation to seniors.

226. Killian, J. R., "New Requirements Imposed on Education by Advancing Technology." Elec. Eng. 75, 1061-3 (Dec. 1956).

J. R. Killian, president of M.I.T., states that, while there is and will continue to be a vast need for four year engineering graduates, there is a fast growing demand for engineering education on the graduate level. There is a great need also for programs that are less vocationalized at the undergraduate level.

227. Killian, J. R., "The Future of Liberal Scientific Education." Jour. Eng. Educ. 46, 793-4 (May 1956).

228. LaRue, Robert D., "How Firm a Foundation." Jour. Eng. Educ. 47, 81-6 (Sept. 1956).

A Department of Pre-engineering is proposed, to integrate at least two years of the engineering curriculum. The major advantage would be to prepare students for realization of what their major fields consist of. Duplication of material (e.g., physics and basic engineering) would be eliminated. The author is a mechanical engineer.

229. Lindvall, F. C., chairman, "Mathematics in Engineering. Report of Pasadena Conference." Jour. Eng. Educ. 46, 585-91 (Mar. 1956).

A one-semester course in differential equations should be required of all engineers. After this, priority should go to a one-semester course in statistical analysis. The mathematical curriculum should contain a two-year series of electives in applied analysis, one year to be taken as undergraduate work and the other in graduate school. Three one-semester elective courses are also recommended:

1. Computers.
2. Probability theory for electrical and industrial engineers and physicists.
3. Maxima and minima of functions for several variables under various kinds of restraints.

Courses in calculus should begin with the freshman year.

230. McCallum, W. W., "Train Engineers for Management." Elec. World 146, 62 (July 16, 1956).

The opinion of the author is that engineering schools should broaden curricula and industry should take over more responsibility for technical training. Utilities and other industries must rely on technically trained men for management positions but find that they don't have the broad background required.

231. McLucas, John L., "A Small Research Company Looks at Engineering Education." Jour. Eng. Educ. 46, 458-60 (Jan. 1956).

Physicists are much stronger on analysis than engineers, and are usually more versatile and adaptable, according to the experience of a small electronics firm. This leads to a feeling that fundamental science is a valuable part of any technological curriculum and that engineers need more of it. They also need to learn English usage.

232. Newberg, W. C., "The Engineer and the Future." Steel Processing 42, 269-73 (1956).

Every engineering graduate should have a broad grounding in economics and an understanding of its application to his work. Another need is the ability to express himself.

Engineers could use more training in management operations, human relations, and sales principles.

233. Oakley, C. O., "Engineering for Mathematicians." Jour. Eng. Educ. 47, 292-5 (Dec. 1956).

The mathematical training given to engineers is reviewed. The author contends that too much time is given to analytic geometry and calculus. He suggests that matrix theory and linear and Boolean algebras are topics which ought to be given.

Mathematicians need to know where engineering is heading, so that engineering students can be taught the mathematics they need. An example is the application of numerical methods to equations not in closed form.

234. Parsegian, V. L., "The Role of Nuclear Courses in Engineering Curricula." Jour. Eng. Educ. 47, 296-300, 348 (Dec. 1956).

The best approach to training engineers for the nuclear age is the integration of nuclear topics into existing degree programs. Only in this way can the various curricula enjoy the benefits of advancing nuclear technology. The courses offered in nuclear technology by R.P.I. are discussed.

235. Parsegian, V. L., "Trends in Engineering Education -- The Need for a New Science Background." Jour. Eng. Educ. 46, 461-6 (Jan. 1956).

A science "package" is proposed, which would bring unity to the early part of engineering curricula. This package would be taught as parallel courses by physicists, chemists and mathematicians, with the utmost emphasis on coordination of subject matter. A two-year series is envisioned, but possibly longer to correlate with early engineering courses.

Nuclear science seems to be the strongest influence for shaping engineering curricula of the future.

Sponsored research is also a strong influence for the better. Research should be an integral part of the educational program.

236. Preble, T. L., Easton, E. C., Simkins, Murray, Horine, H. C., and Stanley, R. L., "Specialized or Basic Engineering Education." Symposium, "Education for Automotive Engineering," Soc. Automotive Engrs. meeting, Jan 10, 1956. Summary in Jour. Soc. Automotive Engrs. 64, 99-100 (Sept. 1956).

Whereas industrialists called for specialized education which equips an engineer for immediate usefulness, educators were unanimous for strengthening engineering principles in the curriculum.

237. Purucker, R. E., "Graduate Study Based on Undergraduate Study in Fundamentals." Jour. Eng. Educ. 47, 223-7 (Nov. 1956).

A committee of the Wisconsin Society of Professional Engineers, deciding that the greatest need of the future is for engineers who are trained for research and prepared for research administration, recommends the following four-year undergraduate curriculum in "Fundamental Science and Engineering":

Mathematics	28 credits
Chemistry	26
Physical Sciences and Engineering	67
General Subjects	<u>24</u>
TOTAL	154

A questionnaire mailed to cooperating research administrators indicated that the course was desirable, and that undergraduates could move into industry upon completion of this course.

The main purpose intended for the course, however, is preparation for advanced work. The committee believes that proper graduate training for research administration consists of broader, more basic, and more theoretical work.

238. Reid, Robert C., "M.I.T.'s Engineering Practice School -- An Effective Transition to Mature Engineering." Jour. Eng. Educ. 46, 441-5 (Jan. 1956).
239. Rohde, F. Virginia, "A Mathematics Teacher Looks at Engineering Courses." Jour. Eng. Educ. 46, 555-9 (Mar. 1956).

The modernization of mathematics courses for engineers is discussed in detail.

240. Seeger, Raymond J., "Progress Report on Physics in Engineering Education." Am. Jour. Phys. 24, 70-7 (1956).

This article summarizes the findings of the Grinter Report of ASEE (Jour. Eng. Educ. 46, 25-59 (Sept. 1955)) with regard to physics in the engineering curriculum, then outlines the history of relations between ASEE and physicists with regard to study of curricular content. Recommendations of the A.I.P. Committee on Engineering Education (Physics Today 8, 12-21 (Dec. 1955)) are summarized.

241. Smith, G. Wallace, "Survey of Instruction in Engineering Mechanics." Jour. Eng. Educ. 46, 536-43 (Mar. 1956).

242. Stevenson, Earl P., "The Scientist-Engineer." Jour. Eng. Educ. 47, 147-53 (Oct. 1956).

The chairman of the board of Arthur D. Little surveys engineering education, and calls for more of the engineer-scientist sort of emphasis in curricula.

243. Walter, John A., "Continuity in English Training for Engineers." Jour. Eng. Educ. 47, 323-5 (Dec. 1956).

Competence in communication is not assured by a sound basic course, even with a follow-up. The following six methods of improving engineers' use of English are discussed:

1. All teachers insist on high-quality writing.
2. Teachers have assistants (English students) who check on student writing quality.
3. Courses in writing correlated with particular engineering courses.
4. A committee on usage, empowered to demand satisfactory attainment in English by graduates.
5. A clinic for assisting students.
6. Training in industry.

244. Warren, S. Reid, Jr., "The Motivation of Engineering Students in the Study of English." Jour. Eng. Educ. 47, 234-8 (Nov. 1956).

Engineering students need to study English so that they can communicate effectively, and need humanities so that they can deal with people. A sample course designed to stimulate student interest in humanities is discussed. The author is an electrical engineer.

245. Wellman, B. Leighton, "Drawing for Tomorrow." Jour. Eng. Educ. 47, 343-6 (Dec. 1956).

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246. Allcut, E. A., "Can Present Mechanical Engineering Curricula Be Improved?" Eng. Jour. 38, 1070-2 (Aug. 1955).

A Canadian educator calls for bifurcation on the basis of mathematics: one program for industry-bound engineers, and a more mathematical program for research- or academically-oriented engineers.

247. Anderson, A. M., "Nuclear Education for Engineers." Jour. Eng. Educ. 45, 678-82 (May 1955).

Two changes are needed in engineering education:

1. Increase the breadth of understanding in the "classical" fields.
2. Improve the understanding of structure of matter and radiation.

An undergraduate nuclear engineering curriculum is not needed, according to the author, who is a training manager for General Electric.

248. Anonymous, "Comments on Interim Report of Committee on Evaluation of Engineering Education." Jour. Eng. Educ. 45, 411-7 (Jan. 1955).

In general, industry strongly indorsed the principles embodied in the report. Most frequent comments were, in order of frequency:

1. Engineers are deficient in expression and in human relations.
2. Corporations can teach practice better than the colleges.
3. Engineers need a broad scientific base and closely allied humanities training.
4. Creative abilities should be developed in students.

The four-year curriculum was favored by a slight majority of the hundred (approximately) respondents.

249. Anonymous, "Criteria for Accreditation Announced by E.C.P.D." Elec. Eng. 74, 1105-6 (Dec. 1955).

The supplemental criteria set forth by the E.C.P.D. are regarded as statements of principles to be used as a yardstick for determining the accrediting of a school. There are seven supplemental criteria described:

1. All curricula shall contain at least one academic year of math and science, equally divided.
2. All curricula shall contain one year of mechanics of solids, fluid mechanics, thermodynamics, transfer and rate mechanisms, electrical theory, and the nature and properties of materials.
3. Because of the flexibility of engineering curricula, other sciences may also be included.
4. One-half of an academic year shall be devoted to analysis, design, and engineering systems.
5. The curriculum shall be designed for an integrated and sequential study in the scientific and engineering area.
6. One-half of an academic year shall represent the minimum content in the area of humanistic and social studies.
7. The pressures for more social-humanistic studies and inclusion of more newly-developed scientific theory make it necessary that neither the technical-scientific nor the social-humanistic content of curricula be reduced below the minimum level to make room for advanced R.O.T.C. training.

The E.C.P.D. committee continues to favor a broad basic undergraduate program.

250. Anonymous, "Results of Education Survey; Broader Education for Engineers is Recommended." Refrig. Eng. 63, 72 (June 1955).

251. Anonymous, "To Manage Materials -- and Men." Chem. Week 76, 24-5 (June 4, 1955).

New trends in engineering education are cited which are intended to broaden engineers' backgrounds. The "three-two" plan may be on the way to universal acceptance, and the humanities are finding more place in curricula.

252. Anonymous, "Trying to Make a New Kind of Engineer; Massachusetts Institute of Technology." Business Week, 64 (May 21, 1955).

Two basic problems face engineering schools today: (1) Where to put the fundamental courses, and (2) which courses to scrap.

There are three possible suggestions for improving both the curriculum and the graduate:

1. Raise the prerequisites for entrance.
2. Increase effectiveness of instruction.
3. Extend the curriculum beyond four years.

A number of schools take a strong stand for the five year course. Schools already having it are Minnesota, Ohio State, Rice and Cornell. All three engineering schools in Los Angeles favor the five-year plan.

253. Armsby, Henry H., "Accreditation of Engineering Curricula." Higher Education 7, 23-30 (Oct. 1955).

Accreditation is explained and is discussed at length. The author makes plain that accreditation criteria are not quantitative.

254. Bray, Oscar S., "Thoughts on Engineering Education." Jour. Boston Soc. Civ. Engrs. 42, 35-8 (Jan. 1955).

Engineering education is good now, but it is turning out good technicians. Another year should be added, and devoted to liberal studies. In this way, engineers would be prepared to operate beyond the technical field.

255. Burdell, Edwin S., "The Humanistic-Social Studies in the Engineering Curricula." Jour. Eng. Educ. 45, 747-52 (June 1955).

The problem of providing engineering students with humanistic-social background is discussed from all viewpoints. The author, president of the Cooper Union, favors a four-year sequence of three-hour courses. This has several advantages: superficiality is avoided by allowing the sequence to advance to profound material in the upper years; teachers can introduce higher standards; greater student maturity can be capitalized upon; the relationship between science and society is made more vivid.

Suggestions are offered for finding the necessary curricular time, including the elimination of descriptive material, postponing more technology until the graduate years, and adoption of a single "engineering science" curriculum. The five-year curriculum is not the answer. Another alternative is use of extra-curricular activities and off-campus cultural activities.

256. Cell, John W., "Mathematics for Graduate Work in Engineering." Jour. Eng. Educ. 45, 423-7 (Jan. 1955).

Undergraduates who plan to enter graduate study should have an additional year of mathematics beyond normal requirements. Graduate students should have at least one more year; M.S. candidates should have the following mathematical subjects in a one-year course:

- I. 1. Complex variables
2. Operational mathematics (Laplace transforms and other transforms)
3. Ordinary and partial differential equations.

Candidates for the Ph.D. should have two additional one-year series, including:

- II. 1. Determinants and matrices
2. Advanced vector analysis
3. Tensor analysis
4. Space geometry
- III. 1. Calculus of variations
2. Integral equations
3. Finite differences and difference equations
4. Perturbation methods and advanced boundary value problems
5. Numerical methods
6. Non-linear problems.

In these last two courses, some of the subjects would be presented rigorously, but in course I the emphasis would be upon total problems, leading to derivations.

257. Chenea, Paul F., "The Role of Engineering Mechanics in Engineering Education." Jour. Eng. Educ. 45, 438-43 (Jan. 1955).

After reviewing the role of mechanics in every way except as regards curricular content, the author discusses liberal education (it should be integrated into engineering courses), Master's theses (they are redundant if courses encourage the proper inquiry), Doctor's theses (every course should contribute directly to the dissertation), and Purdue's new engineering science undergraduate curriculum.

258. Davis, Jess H., "An Administrator Takes a Look at General Studies for Engineers." Jour. Eng. Educ. 46, 109-14 (Oct. 1955).

The engineering approach should be applied to the problem of what general studies should be offered to engineering students. The approach should be functional, tailored to the outlook of the student: O'Neill instead of Shakespeare, jazz instead of Bach, etc.

259. Elgin, Joseph C., "Science for Tomorrow's Engineers." Chem. Eng. News 33, 4296, 4298 (Oct. 10, 1955).

By 1975 engineering science will be the basis of engineering education, and technology and art will have been abandoned. The 1975 chemical engineering curriculum will consist of such engineering science courses as transport processes, fluid mechanics, fluid particle systems, thermodynamics and kinetics, phase equilibrium, phase contacting, and principles of control and information theory.

Nuclear processes will not introduce basically different concepts. The inclusion of liberal courses will be balanced by reduction of empirical material. Knowledge of engineering art should be acquired on the job. Boundaries between engineering branches will almost disappear.

260. Fairbanks, H. V., "The Place of Solid State Physics in Engineering." Jour. Eng. Educ. 46, 251-4 (Nov. 1955).

Solid state physics is finding its way into more and more engineering, and deserves attention in the engineering curriculum. Suggestions include:

1. Infusion of solid state science into existing courses.
2. Replacement of some courses with modern material.
3. Elective courses in solid state physics.
4. Establishment of new courses.

Regular physics courses should include solid state topics. Four semesters of physics should be required of engineers. Applied phases of solid state physics should be left for engineering courses.

261. Foecke, H. A., "Specialists in Diversification." Jour. Eng. Educ. 46, 270-3 (Nov. 1955).

Students embarking upon engineering careers need to develop a "unity of understanding" as early as possible. This need could be answered by instructors who combine a broad background, particularly experience, with a love of teaching -- "specialists in diversification" -- who would introduce the students to engineering.

262. Frank, N. H., "The Role of Physics in Engineering Education." Jour. Eng. Educ. 45, 404-7 (Jan. 1955).

The objectives of physics courses in the engineering curriculum are:

1. To impart a comprehensive, broad background in physics as a cultural subject.
2. To supply a deep quantitative scientific base for an engineering career.

263. Gammel, John, "What Industry Expects of the Young Graduate Engineer." Jour. Eng. Educ. 46, 86-92 (Sept. 1955).

Opinions of industrialists are influenced by their separate interests. In general, they want men who

1. Have basic knowledge and creativity.
2. Have awareness of economic factors.

Except for this, and the desire for desirable attitudes, it appears that "industry likes young engineers to be in their own image."

264. Grinter, L. E., chairman, "Report of the Committee on Evaluation of Engineering Education." Jour. Eng. Educ. 46, 26-60 (Sept. 1955).

In this, the famous "Grinter Report" of the ASEE, the committee announces its searching evaluation of engineering curricula. The time distribution of a modern engineering curriculum should include the following:

Humanistic and social studies	About one fifth
Mathematics and basic sciences (equal weight)	About one fourth
Engineering Sciences	About one fourth
Analysis, design, engineering systems	About one fourth
Electives (any of above, or management, or research)	About one tenth

The engineering sciences are considered to be (1) mechanics of solids, (2) fluid mechanics, (3) thermodynamics, (4) transfer and rate mechanisms, (5) electrical theory, and (6) properties of materials. This is not intended as a complete list, but as a guide to areas which should be included in all engineering curricula.

Mathematics and the basic sciences are the foundation. A minimum level of required mathematics should be established, with differential equations considered to be near this minimum. Modern physics should be in the curriculum, and should virtually replace the semi-engineering variety of physics. Chemistry should be presented in condensed form and should include topics in inorganic, organic and physical chemistry.

Background in all six engineering science is needed by the engineer. Omission of any one should be avoided except after careful consideration and determination that the concepts are covered in other courses at an equivalent mathematical level. A life science or earth science may have a place in specialized curricula.

The committee emphasizes that the engineering science requirements represent the trend of future education.

Engineering analysis and design is the classic component of engineering curricula. Many times these courses are dull and outdated. It is very difficult, but very desirable, to bring the engineering sciences to bear upon these courses in engineering art, so that they become "vital experiences."

Laboratory time should not be spent in stereotyped experiments. The laboratory is the place for the student to observe, test theories, and devise experiments. It is desirable for the students themselves to develop a relatively small number of experiments under effective guidance. Laboratory reports are a primary source of skill in presenting engineering information, and they should not be stereotyped.

Non-departmental courses should not concentrate on devices, but on principles. Shop courses should be critically examined. Graphical expression should be studied as a means of developing spatial visualization and conveying ideas, especially by free-hand sketching; skill in drawing is not desirable for its own sake.

Humanities and social studies will help the engineer realize his fullest development as an individual. The engineer will become an educated man only if the technical and the liberal components of his curriculum are seen as integrated parts of one total program. The recommendation that humanities comprise one-fifth of the curriculum is an endorsement of earlier findings by the ASEE.

The committee recognizes four alternatives as means of adding new curricular material:

1. Raise entrance requirements.
2. Provide better instruction.
3. Eliminate some material from curriculum.
4. Extend length of the curriculum.

The committee has no specific recommendation concerning these alternatives.

Replying to the committee's inquiry, colleges of engineering endorsed the following viewpoints:

1. Higher standards of accreditation should be adopted.
2. Engineering curricula should not be bifurcated into "practical" and "scientific" options.
3. All engineering curricula should be deepened and broadened.

Industrial firms concurred in these judgments, and registered their desire to improve engineers' capacities for communication.

Graduate study has the following objectives:

1. More fundamental understanding of a particular field and underlying related fields.
2. Better methods of analysis.
3. Capacity to read and understand advanced work.
4. Capacity to make new advances.

These objectives are considered more significant than increasing specialization. Another objective of graduate study, in many cases, is continuance of general education at a high level, particularly for prospective engineering educators.

Graduate study, representing as it does a considerable advance beyond undergraduate work, should be more flexible and more suited to the individual. In any case, more mathematics -- a year beyond differential equations for the M.S. and another year for the Ph.D. -- is necessary. Advanced training in engineering science is also necessary, and no graduate student, if he plans to practice research or development, should avoid the opportunity for university research.

Off-campus graduate programs present real dangers if faculty, library, and other facilities are inadequate. It is nearly impossible to maintain standards. In such programs, the parent institution must maintain complete academic control.

At the end of the report, the historical background of previous studies is summarized in an appendix.

265. Grinter, L. E., chairman, "Summary of the Report on Evaluation of Engineering Education." Jour. Eng. Educ. 46, 25 (Sept. 1955).

Recommendations of the committee include:

1. Strengthening basic science in the curriculum
2. Identification of six basic sciences, and their use as a common core of engineering curricula
3. An integrated study of engineering analysis, design, and "engineering systems" for professional background
4. Inclusion of elective subjects
5. An effort to strengthen humanities in the curriculum
6. Insistence on performance in communications
7. Encouragement of experiments
8. Strengthening of graduate studies.

266. Gumpertz, Werner H., "Graduate Study in Building Engineering and Construction." Jour. Eng. Educ. 45, 619-26 (April 1955).

Graduate study should be reserved for serious specialization, not an extension of undergraduate courses. Since it is impossible to teach a man everything about his profession, the student must be founded in fundamentals, and his graduate training must teach him to synthesize.

267. Hawkins, G. A., "Designing the Education Program." Jour. Eng. Educ. 46, 241-6 (Nov. 1955).

An educational program should be designed in the same way that any complex engineering system is designed. The following design principals should be employed:

1. The learning process and motivation, and the laws of learning.
2. An appreciation of the languages of engineering.
3. Understanding of natural laws and concepts.
4. Appreciation of engineering.
5. General mode of analysis.
6. Laboratory experiences.
7. Knowledge of properties of materials.
8. Computational skill.
9. Knowledge of regulation and control.
10. Acquaintance with industrial processes.
11. Appreciation of values.
12. Integration of subject matter for the purpose of design.

The author, dean of engineering at Purdue, has mechanical engineering principally in mind.

268. Hazen, Harold L., "Background and Highlights of Interim Report of Committee on Evaluation of Engineering Education." Jour. Boston Soc. Civ. Engrs. 42, 18-23 (Jan. 1955).

269. Hollister, S. C., "Importance of Engineering Science on the Future of the Profession." Appl. Mech. Rev. 8, 181-2 (1955).

The dean of engineering of Cornell University reviews the trend toward engineering science -- particularly mechanics -- in the engineering curriculum.

270. Hollister, S. C., "Importance of Engineering Science on the Future of the Profession." Mech. Eng. 77, 571-2 (July 1955).

271. Hutchisson, E., chairman, "The Role of Physics in Engineering Education. The Report of a Committee of the American Institute of Physics." Physics Today 8, 12-21 (Dec. 1955).

The purpose of the committee was "to study the role of physics in engineering education and to recommend ways of making the teaching of physics in engineering as effective as possible." The ASEE Committee on Evaluation of Engineering Education had requested the study.

Of the schools responding to the survey, three-fourths offer a physics course of 8-12 semester hours, usually starting in the sophomore year. About 10 per cent of the course is given to atomic physics. Most schools, with the concurrence of the engineering departments, teach physics as a self-sufficient discipline without emphasis on applications.

The following are suggested as goals for physicists who are educating engineering students:

1. Imparting curiosity to students.
2. Imparting appreciation of the limitations and scope of physical interpretations.
3. Imparting underlying principles which are expressed in mathematical terms.
4. Imparting appreciation of the historical development of physics.
5. Teaching the importance of precision.
6. Teaching the importance of objective judgment.

Recommendations of the committee include the following:

1. Improved communication between engineering and physics departments.
2. Early contact of students with physics courses.
3. Improvement of physics laboratory instruction.
4. Emphasis on mathematics in physics courses.

272. Johnson, J. Stuart, "The Integration of Humanities into an Engineering Program." Jour. Eng. Educ. 45, 805-6 (June 1955).

A vertical sequence of humanities is desirable, according to the author, an electrical engineer.

273. Kirkbride, Chalmer G., "Education for Research in Industry." Jour. Eng. Educ. 46, 216-21 (Nov. 1955).

Engineers should not be trained specifically for research, but should be given a broad, intensive education. The engineer of the future must have more understanding of history, economics, philosophy, psychology, government and politics. Training in deductive and inductive reasoning is highly desirable.

274. Leach, Richard H., "Engineering Education from Industry's Viewpoint -- One Man's Impressions." Jour. Eng. Educ. 46, 174-8 (Nov. 1955).

Industry needs engineers who have knowledge beyond their immediate specialty, who can handle human problems, and who can express themselves. Also frequently heard is the complaint that curricula contain much that is of no value in industrial practice -- too much "theoretical" engineering and not enough practical training. The author is a social scientist.

275. LeBold, William K., "Industry Views the Engineering Graduate and His Curriculum." Jour. Eng. Educ. 45, 808-17 (June 1955).

A survey of 85 responses from industries who employ engineers indicated that there was almost unanimous feeling that English and speech should receive increased emphasis. Research and design people favored more advanced science, while those in production and in sales or supervision favored more humanistic-social studies. Opinions were divided on the four-year vs. five-year curriculum. A majority were in favor of an integrated engineering curriculum.

276. Lindahl, Eric J., "Some Suggested Changes and Shift of Emphasis in the Engineering Curriculum." Jour. Eng. Educ. 45, 780-3 (June 1955).

A mechanical engineering educator argues for curricular unification. In particular, the so-called "service course" is criticized.

277. Lockhart, Frank J., "What Is Industry's Responsibility in the Training and Development of Engineers?" Jour. Eng. Educ. 45, 598-602 (April 1955).

Industry can train engineers in practical applications, with the possible exception of small companies for the case of civil and structural engineers. The universities should be responsible for training in the basic areas, and industry for training in the arts.

Ethics and behavior needs more emphasis in the university. Humanities are all very well, but more courses are no substitute for better courses.

278. McNeary, Matthew, "Is Engineering Graphics a Science?" Jour. Eng. Educ. 46, 303-4 (Nov. 1955).

The author believes that graphics, far from being reduced in future curricula, should take its place with engineering sciences.

279. Murphy, Glenn, "Report of the Carnegie Conference on the Impact of Solid State Science on Engineering Materials." Jour. Eng. Educ. 45, 418-22 (Jan. 1955).

There are four ways in which solid state material may be introduced into the engineering curriculum:

1. Enrichment of present courses.
2. Replacement of existing courses.
3. Utilization of available courses as electives.
4. Establishment of new courses.

All four alternatives are discussed, but none is recommended specifically. Many comments from the general discussion of the importance of solid state physics are included.

280. Murphy, Glenn, "The Complementary Role of Physics and Mechanics in Engineering Education." Mech Eng. 77, 573-4 (July 1955).

Physics should not be a prerequisite for mechanics, but instead an introduction to universal physical principles. Engineering mechanics prepares the student for the design of engineering systems.

There should be a course in solid-state physics in the undergraduate curriculum.

281. Odiorne, George S., "The Trouble with Engineers." Harper's 210, 41-6 (Jan. 1955).

A five-year plan, two years at a liberal arts school, is favored for engineering education. The engineer shortage can be more effectively satisfied by a man who is prepared to serve the community as well as the profession.

282. Olmstead, Sterling P., "A Graduate Curriculum in Technical Writing." Jour. Eng. Educ. 45, 587-9 (Mar. 1955).

283. Pollard, William G., "The Value of Research to Graduate Instruction." Jour. Eng. Educ. 46, 226-9 (Nov. 1955).

Unless the research project is a central feature of graduate education, the engineering student cannot be made to feel that he is a part of the professional community.

284. Potter, J. G., "Physics in Engineering Education: ASEE 1954 Annual Meeting." Am. Jour. Phys. 23, 192-7 (1955).

All aspects of physics in the engineering curriculum came under discussion at this meeting. Prominent opinions were (1) physics has a greater place in the curriculum than presently, (2) more modern physics is needed in the curriculum, (3) physics must be taught by physicists, (4) beginning physics should be taught about as it is taught now.

285. Rauch, S. E., "Combined Plans of Study: Arts and Engineering." Jour. Higher Educ. 26, 153-5 (Mar. 1955).

The history of the "three-two" plan is outlined from its inception at M.I.T. in 1936. Under this plan, the student studies for three years at a liberal-arts college, then spends his last two years in an engineering college.

286. Reed, C. E., "Goals of Engineering Education." Tool Engr. 35, 199-200 (Dec. 1955).

Industry expects the graduating engineer to be a problem solver unfamiliar with the details of his chosen industry, familiar with basic scientific tools, and the rudiments of an understanding of human relations. The article is a summary of an address.

287. Rettaliata, John T., "Education by Research Training." Jour. Eng. Educ. 46, 327-31 (Dec. 1955).

An entire student body may be upgraded by permitting selected students to perform laboratory research. These students would receive a new outlook on education, which would be transmitted to other students.

288. Ryder, J. D., "Physics in Engineering -- A Problem in Appraisal." Am. Jour. Phys. 23, 331-6 (1955).

Basic physics should be taught to engineering students in engineering courses. This material should be divided among various engineering departments, so as to reinforce the teaching of fundamental engineering concepts. The physics department would teach about half their present amount, but this time would be given to modern physics.

289. Sanks, R. L., "Place of the Undergraduate Thesis in Engineering Education." Jour. Eng. Educ. 45, 645-8 (April 1955).

The advantages of the senior-year thesis are overwhelming. Advantages in order of importance, are:

1. It requires initiative and resourcefulness.
2. It trains the student to reason and work alone.
3. The student can work entirely on a problem of his own choosing.
4. A survey of the literature is included.
5. Minor advantages: integration of studies, introduction to research, career determination.

The experimental thesis presents the greatest challenge, compared to the design thesis or library thesis. The best administrative method is probably a weekly seminar at which progress is discussed.

Major disadvantage is the time required per credit hour. The experimental thesis may not be a success. The variation in problem difficulty and time required for editing are other disadvantages.

290. Sauer, John A., and Hardenbergh, Donald E., "Physics for Engineers." Jour. Eng. Educ. 46, 349-52, (Dec. 1955)

There should be more, not less, classical physics in the engineering curriculum. The following steps are proposed for physics instruction to engineers:

1. Emphasize fundamental principles.
2. Illustrate the principles with examples from modern physics.
3. Omit extraneous material; avoid the "survey" approach.
4. Use calculus as much as possible.
5. Plan laboratory instruction to develop thought.
6. Introduce basic concepts of nuclear physics.

If institutions provide two years of physics, the new material (item 6) could be added. At other institutions another semester of physics would be required.

With regard to subsequent engineering courses, the following principles should be observed:

1. Specific courses in mechanics, electricity and thermodynamics must be based on fundamental principles, without assuming the student has already mastered them.
2. Engineering instructors should be aware of what is taught in physics; interchange of instructors, which Pennsylvania State University has tried, is desirable.
3. Calculus should be used wherever possible.

291. Seegar, R. J., "Physics Is Not Engineering." Jour. Eng. Educ. 46, 127-31 (Oct. 1955).

292. Sweigert, R. L., "Where Are We Going in Engineering Education?" Jour. Eng. Educ. 46, 247-50 (Nov. 1955).

Engineering education must prepare students for professional careers, not merely careers as technicians. To this end, engineering is becoming much more scientific. Bifurcation exists in fact, if not in theory, because of the division between professionals and technicians, and this can be acknowledged by differences in choice of electives.

Education requires attention to liberal studies but these must not dilute the professional curriculum. Liberal studies also have a place at the graduate level, where they have hitherto been ignored.

Professional status demands education beyond the undergraduate level. Either graduate study or persistent individual study will fill this need. Off-campus graduate programs in engineering reveal the need.

Perhaps engineering education should be integrated so as to present only two divisions: the physics-oriented and the chemistry-oriented engineer, at the undergraduate level. Then, by graduate study, the student could enter a particular field.

293. Thomas, G. B., Jr., chairman, "Report of the Joint Committee of the American Society for Engineering Education and the Mathematical Association of America on Engineering Mathematics." Jour. Eng. Educ. 45, 583-8 (April 1955).

The Mathematical Association of America has devised a first year mathematics course for all students who study mathematics in college, with supplementary material for engineers. The freshman engineering mathematics curriculum would consist of a five-hour course including graphical analysis, Newton's methods, numerical integration, rate problems, binary representation, computing machines, centroids and moments of inertia, finite differences, tables of normal probability, and a few other topics, all in addition to the basic course taken by all students.

In the second year, engineering students would receive a course in calculus and analytic geometry with applications using vector methods, including linear differential equations with constant coefficients. The program has been successfully applied at Tulane. The joint committee does not necessarily endorse the M.A.A.'s proposed program.

The committee concluded that there was considerable sentiment for the following:

1. All engineers should receive mathematics through differential equations.
2. Statistics and probability deserve more attention.
3. Students should be able to elect more courses in mathematics.

The committee also recommends more emphasis on numerical and graphical methods and on fundamental concepts, and more use of mathematics in junior and senior engineering courses.

294. Tichenor, George, "Interrupting the Great Conversation." Tech. Rev. 57, 241-4, 260, 262, 264, 266 (Mar. 1955).

Humanities should be optional in technical schools. There is no proof that they have ever made men more democratic, and their presence in a technical curriculum at the expense of useful courses is merely gratification of a contemporary fad.

295. Warner, J. C., "The Value of Research to the Education Program." Jour. Eng. Educ. 46, 338-41 (Dec. 1955).

The student should be introduced to research as a freshman, then he should encounter longer and longer problems which would culminate in theses in senior and graduate work.

Research influences the curriculum by its effect on educators. Those who do research can evaluate what is really important in their field.

296. White, William C., "Humanistic-Social Content of Engineering Curricula." Jour. Boston Soc. Civ. Engrs. 42, 24-9 (Jan. 1955).

The present situation regarding humanistic-social studies is surveyed. Then the possible methods for introducing this material into the curriculum are surveyed.

297. Wilbur, John B., "Limitations of Logic in Engineering Education." Tech. Rev. 57, 233-6, 256, 258-9 (Mar. 1955).

The engineering curriculum is well designed to develop the student's logical sense, but perhaps endangers his "informal" faculties of judgment, imagination and intuition. After being introduced to exact sciences in the first years of his training, in his later years the student must readjust to the need for inexact reasoning.

The author, a civil engineer, proposes a vertical curriculum in which exact science, engineering, and the humanities go forward simultaneously, so that there is simultaneous development of logical and informal faculties. A concept of the total would be acquired before the parts are closely studied.

An illustrative freshman problem in civil engineering is outlined for example's sake.

298. Wilson, Warren E., "Problems in Communication in the Engineering Science Curriculum." Jour. Eng. Educ. 46, 374-8 (Dec. 1955).

Pennsylvania State University's engineering science curriculum, in which no specialized degree is granted, is described. This curriculum was established in 1953.

299. Wolfe, John K., "Evaluation of Engineering Education." Jour. Eng. Educ. 46, 342-8 (Dec. 1955).

A placement director has assembled the comments of about 160 electrical executives and managers of the General Electric Company, regarding the Interim Report of the ASEE Committee on Evaluation of Engineering Education. These industrialists rate the need for better expression above social studies.

Concerning graduate study, respondents felt a definite need for highly specialized graduate engineers. Some engineers with advanced degrees, however, should be broadly trained in order to prepare for management. Undergraduates should generally be trained broadly.

There is a real need for off-campus graduate study. It should not be outlawed.

1954

300. Abbott, J. P., "Modern Engineering Physics from the Viewpoint of an Administrator." Jour. Eng. Educ. 44, 442-8 (April 1954).

This is a survey of the position of physics in the engineering curriculum, by the dean of Texas A & M.

301. Anonymous, "Take a Look at Correspondence Courses." Chem. Eng. 61, 222 (Dec. 1954).

302. Beck, Clifford, "Report on ASEE Summer Institutes on Inclusion of Modern and Solid State Physics in the Curricula of All Engineers." Jour. Eng. Educ. 45, 254-7 (Nov. 1954).

Two schools of thought emerged from the summer institutes sponsored by ASEE and NSF. One school of thought was for revision of general basic physics courses, either by eliminating non-fundamental material or by modernizing content. The second prominent opinion was for addition of new material: (1) three semester hours of modern physics and (2) three semester hours of solid state physics, both above the general physics level.

Nuclear engineering curricula were discussed. Most felt that this curriculum was best suited for graduate specialization. The author, head of the Physics Department of North Carolina State, cites three reasons why that school's undergraduate nuclear engineering curriculum is successful:

1. High prestige value.
2. Heavy demand for graduates.
3. Sound curriculum.

303. Boelter, L. M. K., "Professional Engineering in Education." Paper No. 54, presented at Am. Soc. Mech. Engrs. Meeting, Sept. 13-24, 1954. 9 pp.

304. Booker, H. G., "What Is Wrong with Engineering Education?" Proc. I.R.E. 42, 513 (Mar. 1954).

The principal function of undergraduate education should be to develop the mind of the student by having him think through things that other people have frequently thought through before. Research is stressed as the basic tool for graduate education.

The refusal of engineering educators to use engineering as a basis for education is the illness of today's engineering education.

305. Boyajian, A., "The Final Course. Dress Rehearsal for Practice." Jour. Eng. Educ. 44, 394-6 (Mar. 1954).

The entire second semester of the senior year could profitably be given to an introduction to engineering practice. Even if engineers are well trained in fundamentals, they will need the ability to apply the fundamentals.

Four practical projects in different fields would provide the needed variety. Each project would be carried through the stages of study, literature review, field or laboratory experiment, design, costs and final engineering report.

306. Bronwell, A., "Basic Conflicts in Engineering Education." Mech. Eng. 76, 886-90 (Nov. 1954).

There are several irreconcilable conflicts in engineering education: lack of curricular space for needed subjects, unified curriculum vs. specialized curriculum, functional social studies vs. purely cultural studies. All viewpoints are reviewed in this article.

Three new concepts of engineering educations are noted: strengthening of mathematics and basic sciences, new areas of technology, and the movement toward a balanced curriculum.

307. Dawson, Charles H., "Servomechanisms in the Undergraduate Curriculum." Jour. Eng. Educ. 44, 617-9 (June 1954).

308. Everitt, W. L., "The Place of the Socio-Humanistic Studies in Professional Graduate Instruction." Jour. Eng. Educ. 45, 69-72 (Sept. 1954).

Graduate schools should devote more attention to a social-humanistic stem for technical students. The author's argument may be summarized as follows:

- a) The engineering undergraduate is intensely interested in technical studies, but too immature to recognize value in humanities.
 - b) It is the graduate students who will become educators and leaders.
- Thus the author urges concurrent social-humanistic studies from beginning to end of a student's education.

A minor in cultural courses is one alternative. A personal cultural program, planned by the student in consultation with a professor, is another.

309. Grinter, L. E., "Education for a Creative Professional Life." Jour. Eng. Educ. 45, 7-13 (Sept. 1954).

In his presidential address, the retiring president of ASEE reviews the forces at work for changing engineering curricula. It seems less probable that additional specialized curricula will develop in the future. There may even be some combinations, with specialization reserved for graduate study. The recently (June, 1954) released Interim Report of the Committee on Evaluation has suggested a "common stem," of about a hundred hours for engineering curricula.

The importance of graduate work is underlined. The author calls for a survey of the present status of graduate study, with improvement of objectives and standards as the goal. The author also predicts increasing importance for graduate study, in view of the heavy pressures on the four-year curriculum.

310. Grinter, L. E., chairman, "Interim Report of the Committee on Evaluation of Engineering Education." Jour. Eng. Educ. 45, 40-66 (Sept. 1954).

This is the preliminary version of the "Grinter Report" (Jour. Eng. Educ. 46, 26-60, Sept. 1955)). The only concept in this Interim Report which does not appear in the final report is the concept of the "common stem" for engineering curricula, which is treated less explicitly in the final report. A suggested curriculum is the following:

Humanistic - social	21 semester hours
Math and basic science	36
Engineering science	36
Technology	7
Total for common stem	<u>100</u>

Major department sequence	21 semester hours
Electives (technical and otherwise)	<u>17</u>
	38
Common stem	<u>100</u>
Total for four-year curriculum	<u>138</u> semester hours

In the Interim Report there are considered to be nine engineering sciences: (1) statics, (2) dynamics, (3) strength of materials, (4) fluid flow (5) heat flow, (6) thermodynamics, (7) electrical currents, fields and electronics, (8) engineering materials, and (9) physical metallurgy. The final report considers only six engineering sciences.

Appendix A summarizes previous evaluation studies.

311. Grinter, L. E., "Physics for Engineers in the Mid-Fifties." Am. Jour. Phys. 22, 464-7 (1954).

The chairman of the ASEE Committee on Evaluation of Education discusses the need for modern physics in the engineering curriculum. More physics is needed by engineers, but the proportion of modern physics should be higher than at present.

312. Grinter, L. E., "Physics for Engineers in the Mid-Fifties." Jour. Eng. Educ. 45, 246-50 (Nov. 1954).

Duplication of elementary physics material in engineering courses needs to be reduced, and modern physics emphasized.

313. Hamburger, F. "Education for the Profession." Proc. I.R.E. 42, 1061 (July 1954).

The prospective engineering student of today is faced with two alternatives: (1) prepare himself in such a way that after completion of studies he can be immediagely productive and useful or (2) seek a broad fundamental knowledge which will probably require a longer apprenticeship but result in a longer period of productivity. The pressure of immediate productivity tends to force schools into alternative (1), but the schools' duty to the profession and society dictates alternative (2) in order to uphold progeSSIONal quality and achieve social maturity.

314. Hancher, Virgil M., "Liberal Education in Professional Curricula." Jour. Eng. Educ. 44, 356-61 (March 1954).

A certain amount of liberal subject matter in the curriculum will not result in a liberal education. The liberally educated man is one who views all his learning in a liberal manner. The duty of the colleges is to provide this liberal outlook.

315. Houston, R. W., "Report of Summer Institute Preliminary Conference on Nuclear Physics in Engineering Education." Jour. Eng. Educ. 44, 573-80 (June 1954).

The conference did not emphasize how to introduce nuclear material into the curriculum, but dwelt instead on course content. The general feeling was that an undergraduate nuclear engineering degree is unwarranted. One or two courses, however, should be available to undergraduates, and many examples from the nuclear field could be used in existing courses.

316. Hrones, J. A., "Role of Measurement and Instrumentation in Engineering Education." Paper No. 54-IRD-8 presented at Am. Soc. Mech. Engrs. meeting Sept. 13-24, 1954. pp. 3.

A sound training in the engineering sciences can exist only if the problems of measurement and instrumentation are integrated into these courses.

317. Jeffries, R. J., "Instrumentation Problems in University." Paper No. 54-IRD-9 presented at Am. Soc. Mech. Engrs. meeting, Sept. 13-24, 1954. pp. 5.

318. Murphy, Glenn, "ASEE Summer Institute Conference on Solid State Physics in the Engineering Curriculum." Jour. Eng. Educ. 44, 494-7 (May 1954).

Two course outlines were evolved: a three-credit course in atomic and solid state physics, and a sequence of two three-hour courses, one on each of the two topics. These are designed for engineers rather than physicists, but there was no discussion of their logical place in the curriculum.

319. O'Brien, M. P., "Graduate Professional Education in Engineering." Jour. Eng. Educ. 44, 545-52 (May 1954).

The emphasis in graduate engineering education must be shifted from its present inflexible position toward the ideal of individual study.

320. Sawyer, Herbert A., Jr., "Axioms of Curriculum Change." Jour. Eng. Educ. 44, 610-1 (June 1954).

The following are considered axiomatic, based on the author's study of the writings of many colleagues:

1. Additions must be matched by deletions.
2. Overlapping of course content has some advantages.
3. The undergraduate years merely initiate professional training.
4. Bifurcation (on the basis of ability) is coming.

321. Shumaker, C. H., "Training Engineers . . . A Mutual Job for Colleges and Industry." Mech. Eng. 76, 814-5 (Oct. 1954).

The possible methods of putting more material into the engineering curriculum are reviewed. Industry's obligations to the schools and to its young engineers are listed.

322. Smith, J. F. Downie, "Improving the Teaching of Engineering." Jour. Eng. Educ. 45, 73-9 (Sept. 1954).

Liberal arts should be injected into the teaching of engineering courses. The "direct teaching of cultural subjects, without vocational purpose," is not necessary.

323. Turin, John J., "Is Closer Integration an Answer to Crowded Curricula?" Jour. Eng. Educ. 44, 340-2 (Jan. 1954).

Closer integration of introductory courses (i.e., physics and mathematics) will ease some of the pressure on engineering curricula.

1953

324. Anonymous, "Accrediting and Evaluation Discussed at ASEE-ECPD Meeting." Mech. Eng. 75, 1037-9 (Dec. 1953).

325. Anonymous, "American Society for Engineering Education and Engineers Council for Professional Development Joint Meeting, New York." Chem. Eng. News 31, 4434, 4437 (Oct. 26, 1953).

At the meeting, L. E. Grinter proposed a bifurcated undergraduate engineering curriculum. If professional courses are added to the "scientific" branch of the curriculum, four years may not be sufficient time.

326. Anonymous, "Engineers, Educators Propose Changed Engineering Education." Machine Design 25, 251-2 (Dec. 1953).

A proposal emanating from a joint ASEE-ECPD meeting calls for a bifurcated curriculum: professional-scientific and professional-general.

327. Anonymous, "Important Need in Engineering Education; ASEE 61st Annual Meeting, Gainesville, Fla." Mech. Eng. 75, 681-2 (Aug. 1953).

Among the speakers, L. E. Grinter cited the need for more science in engineering curricula.

Another speaker, J. W. Parker, stressed that training in nuclear engineering should be the same as in other fields, but should include more mathematics.

328. Anonymous, "Letters on Engineering Education." Midwest Engr. 5, 24-5 (March 1953); 21, 23 (April 1953); 22-3 (May 1953).

Respondents indicated a need in engineering curricula for writing and speaking, humanities, business courses, and management courses. Engineers were believed technically competent.

329. Anonymous, "Slide Rules and Executive Posts." Business Week, p. 48, (Dec. 26, 1953).

A majority of executives feel that engineers are lacking in other fields of knowledge. Many engineers agree, citing a need for more work in English, liberal courses, and business administration.

330. Armsby, Henry H., "The 'Three-Two' Plan -- An Educational Experiment." Higher Education 10, 61-4 (Dec. 1953).

The "three-two" plan provides for a three-year liberal arts curriculum, followed by two years in engineering school. All the student's basic science and mathematics are obtained in the first three years. The plan has the advantages of allowing the student to achieve more maturity before deciding on an engineering career, and removes the difficulty of inserting liberal studies into the engineering curriculum.

Opinions are reviewed, and schools using the plan are listed in this article.

331. Boelter, L. M. K., "In-Service Training for Research and Development." Appl. Mech. Rev. 6, 489-90 (1953).

The training which research and development engineers should receive on-the-job is described in this article. Engineering graduates, trained for analysis, must develop their powers of synthesis after graduation.

332. Boelter, L. M. K., "Unified Engineering Curriculum." Gen. Elec. Rev. 56, 12-14 (Nov. 1953).

The unified engineering curriculum is adequate for the engineer seeking employment where specialized on-the-job training is available or in a position where a large variety of problems involving broad basic concepts are encountered.

A detailed description of engineering curricula is given. Content of the unified curriculum, confined to fundamentals, is discussed at length.

The theory of a unified curriculum is for all undergraduate engineers to receive the same basic engineering course. The emphasis in this course is on problem solving.

An attempt is being made to put mechanics on an experimental experience basis. The techniques of circuit analysis are being applied to systems other than electrical. Considerable attention is being given to reducing the time gap between related courses. Physiology, psychology, and biotechnology are being experimentally introduced into the engineering curriculum. The uses of materials are being given considerable attention with both an analytic and experimental approach.

333. Boyajian, Aram, "Education of Tom, Dick, and Harry." Tech. Rev. 55, 262-4, 280, 282, 284, 286 (March 1953).

A new emphasis on engineering education should be considered. The suggested rearrangement would create fields of (1) manufacturing engineering, (2) developmental engineering, and (3) application engineering, to replace the usual branches. This would more nearly agree with the temperamental and employment probabilities of engineers.

334. Doan, Gilbert E., "Stronger Engineering Graduates." Jour. Eng. Educ. 43, 534-6 (May 1953).

Graduates should leave the engineering colleges with a rational life view, which is not now being provided for them.

335. Farrar, G. L., "University-Level Course in Process Instrumentation." Instruments 26, 406-10 (1953).

A thorough description of a minimum acceptable course for the modern process engineer is presented. The general outline is as follows:

1. Introduction to instrumentation
2. Measurement
3. Responses of measuring instruments
4. Automatic controllers
5. Final control elements
6. Characteristics of processes
7. Application of control responses to various processes
8. Automatic control systems

Each of the above points is discussed in detail. The course is designed for an eighteen-week semester with a four-hour laboratory period each week. Prerequisites are physics, chemistry, mathematics and unit operations.

336. Grinter, L. E., chairman, "Summary of Preliminary Report. Committee on Evaluation of Engineering Education." Jour. Eng. Educ. 44, 143-7 (Nov. 1953).

This report outlines the objectives and the background of the ASEE's evaluation study, begun in 1952. For the findings of the Committee, see the Interim Report (Jour. Eng. Educ. 45, 40-66, (Sept. 1954)) and the Final Report (Jour. Eng. Educ. 46, 26-60, (Sept. 1955)).

337. Harrisberger, Lee, "Improving the Product." Jour. Eng. Educ. 44, 82-7 (Oct. 1953).

Engineering graduates need a broader background in fundamentals. To this end, the necessary mathematical background should begin with calculus in the freshman year. In the second year differential equations, Fourier series, Laplace transform, statistical analysis and nomography should be offered.

Also in the freshman year, advanced chemistry and physics should be offered. The second year should see the introduction of engineering science courses: mechanics, thermodynamics, electricity and electronics, fluid mechanics, metallurgy, etc.

The first two years should also include liberal courses: philosophy, psychology, logic. There should also be courses in speech, technical writing, descriptive geometry and elements of visual presentation during these years.

In the last two years of his curriculum, the student would have considerable freedom to choose certain percentages of major courses, minor courses, and cultural-humanistic courses.

The student's major should fall into one of three areas: (1) research, (2) production and design, or (3) sales and management.

The author is a mechanical engineering educator.

338. Hollister, S. C., "Five-year Engineering Program." Gen. Elec. Rev. 56, 10-12 (Nov. 1953).

Weaknesses of the four-year engineering curriculum pointed out by the author include:

1. Current four-year programs are not adequate to provide proper depth for the present day general practitioner engineer.
2. The fact that industry has to resort to technical education programs is a sign that the colleges are not doing their job.
3. The average four-year program is designed to terminate in four years, thereby limiting in advance the amount of subject material.

The "three-two" program and the possibility of making engineering entirely a graduate program are discussed but discarded because of curricular financial difficulties that would be involved.

If the broad fundamental training requirements being set forth by industry are to be met by the colleges, a five-year undergraduate program is necessary.

339. Houston, W. V., "Does College Make an Engineer?" Oil Gas Jour. 52, No. 1, 225-6, 315-6 (Nov. 16, 1953); Proc. Am. Petrol. Inst. 33, 78-84 (1953).

College does not make an engineer; only experience can do this. The university gives the student a general education and a scientific background.

The curriculum of Rice Institute--of which the author is president--is designed to award a bachelor of arts degree after four years of study, and a specific engineering degree after a fifth year of study.

Probably there will develop a scheme of engineering internship analogous to medical internship. This may come about as an extension of the already customary postgraduate training program.

340. Howland, W. E., "What can the Engineering Schools Do About It?" Jour. Eng. Educ. 44, 212-3 (Nov. 1953).

The schools should concentrate on educating professional engineers instead of producing practical men of business. The title refers to corruption in public places.

341. McEachron, K. B., Jr., "Why Options Anyway?" Elec. Eng. 72, 305-6 (April 1953).

Industry is becoming less and less interested in the engineering graduate who thinks he is a specialist, who wants to know "more and more about less and less until he knows everything about nothing," says Robert Sprague of the Sprague Electric Company. One of the three basic requirements in the education of engineers is "intensive training in the basic and applied sciences, even at the expense of applied engineering subjects."

The "option" system of today causes a lack of interest by students toward other phases of engineering. One method of correcting this attitude would be to include engineering problems of all types, starting with the freshman year, in order to produce in the student the realization of the need for a knowledge of the sciences and mathematics. In this way the engineering student would also gain a broad knowledge of his field and will be better equipped to handle problems involving knowledge outside of his specialty.

342. Piper, Henry Dan, "English and History as Professional Equipment for the Engineer." Jour. Eng. Educ. 43, 460-4 (April 1953).

The engineer needs English so that he can communicate, and history so that he can maintain a historical perspective. To make room for these in the crowded curriculum, it is recommended that the student demonstrate, before graduation, a command of English and a historical sense as they apply to his field.

343. Pletta, D. H., "Selected Reports by Institutional Committees on Evaluation of Engineering Education." Jour. Eng. Educ. 44, 257-72 (Dec. 1953).

The secretary of the ASEE Committee on Evaluation of Engineering Education introduces abstract reports from seven institutional committees: Stanford University; University of California, Los Angeles; Cornell University; Johns Hopkins University; McGill University; Oregon State College; and Illinois Institute of Technology. Beyond agreeing that a broadening trend is desirable, and that humanities have a place in the curriculum, these abstract reports make no specific statements regarding curricula.

344. Smith, J. F. D., "Four-year Engineering Program." Gen. Elec. Rev. 56, 8-10 (Nov. 1953).

The four-year engineering program will continue to supply the largest portion of industry's engineers, but there is a growing demand for engineers on the graduate level. In order for tomorrow's engineers to be properly rounded and prepared for civic and professional obligations, there must be an eight-year program, beginning with high school. By beginning the engineering education in high school much time could be saved.

345. Smith, Ralph J., "Education for the Engineering Spectrum." Jour. Eng. Educ. 44, 88-93 (Oct. 1953).

The most feasible way of meeting the increasing demands on engineering education is to limit the number of objectives required of students. This can be done by eliminating the current specialties in favor of functional specialization. This means educating engineers for the function they are to fulfill: research, development, production, construction, etc.

346. Sprague, Robert C., "Training Engineers for More Effective Results in Industry." Jour. Eng. Educ. 43, 451-6 (April 1953).

Basic sciences should be stressed in the curriculum, because the man with the strongest basic training is the most adaptable. Industry could assume more responsibility for specialized training.

Continued increase in humanistic studies (including economics and business) is desirable, as is exercise in teamwork. The author is an electrical industry executive.

347. Sproul, Robert G., "A University President Looks at Engineering Education." Civ. Eng. 25, 394-5 (June 1953).

A review of current trends, particularly in California, is given.

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348. Anonymous, "Future may Require Longer than Four-Year Engineering Curriculum; Largest Conclave of Engineers Attacks Problem of Personal Shortage." Chem. Eng. News 30, 3830-1 (Sept. 15, 1952).

Among ideas brought out at the Symposium on Education and Training, in conjunction with the Centennial of Engineering Convocation at Chicago, were the following:

Dean S. C. Hollister of Cornell foresaw more extended engineering programs.

Bell Telephone's Oliver E. Buckley cited the need for more graduate courses in industry or in cooperation with universities.

General Electric's Maynard M. Boring said that engineers must continue to broaden themselves. Industry must help do this.

349. Armsby, Henry H., "Engineering Education in the United States." Higher Education 9, 73-82 (Dec. 1, 1952).

All facets of engineering education are reviewed. Current curricular problems -- objectives, specialization, liberal content, length -- are outlined.

350. Barker, George J., "Four Year vs. Five Year Engineering Course." Jour. Eng. Educ. 42, 460-2 (May 1952).

The four year curriculum should be retained, but course content should be strengthened. Emphasis should be placed on a mastery of fundamentals. Specialization should be left to graduate school or to the employer.

351. Boelter, L. M. K., "Looking Ahead in Engineering Education." Jour. Eng. Educ. 43, 249-57 (Dec. 1952).

The undergraduate curriculum will lose its emphasis on fragmentation and separate disciplines. Social-humanistic studies will become an integral part of the curriculum. One of the strongest unifying forces in undergraduate curricula will be the science of engineering materials.

Graduate education will develop along two paths: the discipline of research and the discipline of the design of engineering systems. Graduate education will also see greater emphasis on social-humanistic content.

352. Boyd, James. H., "What Type Education -- Specialized or Fundamental?" Chem. Eng. Prog. 48, 371-3 (1952).

A curriculum attempting to train students in a professional specialty is bound to fail. A basic scientific training is best.

353. Brown, Gordon S., "The Modern Engineer Should be Educated as a Scientist. II. In College." Jour. Eng. Educ. 43, 274-81 (Dec. 1952).

In addition to increased emphasis on basic science and mathematics, the curriculum should allow student participation in research or make frequent use of the case method of instruction.

354. Doan, G. E., "Stronger Engineering Graduates." Mech. Eng. 74, 877, 908 (Nov. 1952).

355. Eshback, O. W., "Encouragement of Technical Training for Young People." Elec. Eng. 71, 869-71 (1952).

At the present time there is a large deficiency of engineers. One recommendation is training on an intermediate level so that engineers can be utilized only for engineering jobs. Young people need to be interested in engineering as a career and an elementary foundation in science and mathematics in high school is emphasized.

356. Gibbons, Eugene F., "Is Specialized Engineering Needed?" Petrol.Proc. 7, 615-9 (1952).

The refining industry wants specialized engineers, and specialized training at the undergraduate level is being encouraged. Educators, however, largely feel that an engineering graduate should have a broad training, with specialization reserved for graduate study.

It is not true that specialization limits the graduate. His training is fundamental, and is merely applied with a specific purpose.

357. Grinter, L. E., "Questions Concerning the Engineering Curriculum." Jour. Eng. Educ. 42, 261-2 (Jan. 1952).

The emphasis on specialization in the curriculum seems to have begun to wane. Because of the needs of research and administration, and the great variety of functions which engineers now perform, the curricula are drawing together again.

Students must be broadly educated, must have a detailed background of physical science and mathematics, and must have a respect for economics. If these things are all to be in the curriculum, then the curriculum needs re-examination in order to find room for them.

The author suggests curricula based upon professional objectives: design courses for the designer, more non-technical courses for the non-professional engineer, etc.

358. Hammond, H. P., "What Engineering College Will and Will Not Do for Student." Mech. Eng. 74, 217-8 (March 1952).

Among things which the college will not do are the following: give the student an appreciation of his position as a citizen, help the student develop originality, teach the application of basic laws rather than derived formulas.

359. Hollister, S. C., Crouse, C. S., Grant, L. F., and Hooven, M. D., "Adequacy and Standards of Engineering Education." Elec. Eng. 71, 27-30 (Jan. 1952).

Current accrediting procedures relate almost entirely to minimum standards and that this practice leads to complacency among the schools that barely satisfy such a standard.

The general trend has been to overcrowd the four-year curriculum to meet the demand for more general education and at the same time maintain high standards of engineering education.

A pre-engineering school has been suggested to bring the engineering student to a desired level before entering engineering study.

360. Hollister, S. C., chairman, "Adequacy and Standards of Engineering Curricula." Mech. Eng. 74, 15-8 (Jan. 1952).
361. Hollister, S. C., "Looking Ahead in Engineering Education." Jour. Eng. Educ. 43, 258-62 (Dec. 1952).

The basic science content of engineering curricula must be strengthened.

362. Hollister, S. C., Crouse, C. S., Grant, L. F. and Hooven, M. D., "Report of Committee on Adequacy and Standards of Engineering Education." Jour. Eng. Educ. 42, 249-54 (Jan. 1952).

The current position of engineering curricula is reviewed broadly. It is concluded that curricula should be based upon the fundamental sciences and especially upon mathematics. It is mentioned that architecture is far ahead of engineering in teaching students to solve problems creatively.

363. Ihrig, Harry K., "The Modern Engineer Should be Educated as a Scientist. I. In Industry." Jour. Eng. Educ. 43, 269-73 (Dec. 1952).

From the industrial standpoint, a curriculum of non-specialized engineering would be useful, consisting of the following:

Mathematics	28 credits
Chemistry	26
Physics	33
Engineering fundamentals	33
Humanities	24
	<u>144 credits</u>

This would lead to a B.S. in engineering. A committee of industrialists, including representatives of small industry, has made this recommendation in cooperation with the University of Wisconsin.

The author cites the graduate program offered by Allis-Chalmers in cooperation with Illinois Institute of Technology. The school directs the program, but the company provides the thesis topic or else the equipment for the student to use.

In the absence of universal agreement regarding a fundamental curriculum, it is recommended that the fundamental course be offered as an alternate to existing courses.

364. McEachron, K. B., Jr., "Tomorrow's Engineer, In Preparation." Elec. Eng. 71, 597-602 (July 1952).

In order to provide enough engineers for the future, secondary and primary school age groups need more training in science and mathematics. Also techniques need improvement at the college level.

The proper use of comprehensive problems that stress the basic laws are characterized in five ways:

- (1) Problems should be of such a nature that the student would have to arrive at conclusions on his own initiative.
- (2) They should be devised so that the student must decide the best angle of attack.

- (3) Problems should deal with real situations to help provide motivation and a sense of accomplishment.
- (4) Some problems should be assigned orally so that the student must clarify the situation and discover and state his immediate goal for himself.
- (5) The problems should be carefully examined by the teacher, comments noted on paper, promptly returned and discussed fully in class.

365. McMillan, F. D., "Our Heritage from Engineering Education." Elec. Eng. 71, 487-91 (1952).

The engineering curriculum must not become molded and rigid. It must remain unrestrained, free to exercise originality and improve itself. The requirements imposed on the engineering curriculum are constantly changing.

366. Saville, Thorndike, "Achievements in Engineering Education." Jour. Eng. Educ. 43, 222-35 (Dec. 1952).

The curriculum trends of the previous 50 years are surveyed in general terms. Increasing rigor and basic emphasis are noted, as are the increasing numbers of specialized curricula, and the emphasis on social-humanistic studies.

367. Shurter, R. L., "Today's Education and Tomorrow's Engineer." Gen. Elec. Rev. 55, 7-12 (Sept. 1952).

It is the opinion of the author that the engineer should be prepared to perform properly as a citizen as well as a professional engineer. The following aims are considered fundamental:

1. To prepare the engineer to express his ideas clearly and concisely in both speaking and writing.
2. To give him an understanding of and convictions about his responsibilities as a citizen in a democracy.
3. To provide him with a knowledge of the background of the social organization within which he lives and of the great expressions of the human mind concerning man and society.
4. To stimulate his interest in some aspect of the humanities or social studies as a basis for continued study or pleasure in these pursuits.

368. Taggart, Arthur F., "Education for Engineering." Jour. Petrol. Tech. 4, 15 (Sec. 1), 3 (Sec. 2) (May 1952).

The engineer is incomplete unless he can handle problems in six basic fields: materials, stationary structures, energy transformation, machines, process elements, and approximation. In addition, humanistic studies are necessary.

369. Taggart, Arthur F., "Education for Engineering." Mining Eng. 4, 770-4 (Aug. 1952).

Engineering education should consist of fifty per cent basic science and fifty per cent study of man through literature, history, biology and economics. Industry is asking for men trained in basic fundamentals and asking that the specific subjects be left for industry to teach. Undergraduate school is where the engineer should gain the foundation work; specifics should be taught in graduate school.

370. Vidosic, J. P., "Undergraduate Machine Design." Machine Design 24, 242, 244, 246, 248 (June 1952).

Theory should be emphasized in undergraduate machine design instruction at the expense of empiricism. Empirical methods enter only after theoretical analysis, and the problems should emphasize this.

371. Warner, J. C., "Engineering Education in a Free Society." Paper presented at Chicago Regional Technical Meeting, American Iron and Steel Institute, Sept. 11, 1952.

This paper by the president of Carnegie Institute of Technology summarizes the trend of engineering education toward a broader scientific base.

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372. Barnard, N. H., "Accident Prevention and Safety. A Vital Course in the Engineering Curriculum." Mech. Eng. 73, 814-5 (Oct. 1951).

373. Eckles, Robert B., "Engineering Education and the Social Sciences: a Criticism." Jour. Higher Educ. 22, 476-9 (Sept. 1951).

Engineers are "social illiterates" who do not realize that inductive reasoning will not solve human problems. In the future more time must be given to general-education courses in the engineering curriculum.

374. Hannah, John A., "Lustre or Glitter?" Jour. Eng. Educ. 42, 18-23 (Sept. 1951).

The graduate needs training narrow enough to earn him a living, while broad enough to equip him to make a life. A college's duty is to turn out educated men.

375. Hannah, John A., "Lustre or Glitter?" Machine Design 23, 228, 230, 232, 234 (Sept. 1951).

The glitter of civilization's material achievements is no substitute for the lustre of civilization itself. Engineers with no education in humanities are only half educated.

376. Henson, R. D., "Development of Engineering as a Profession." Elec. Eng. 70, 213-7 (March 1951).

An instructor of engineering law at the University of Illinois says that the trend in engineering education on the undergraduate level is general, both in engineering subjects as well as in other fields of

knowledge, with specialization on the graduate level. "The public expects leadership from members of a profession, and engineers individually and collectively must be prepared to meet that expectation and to fulfill their obligations with distinction."

377. Halland, Malcom B., and Bell, Kenneth A., "Survey of Industrial Instruments Courses in Engineering Schools." Instruments 24, 886-7 (Aug. 1951).

In 1949, the Engineers' Council for Professional Development sent a questionnaire to 136 accredited schools. This article gives the questions and replies to the questions and an analysis as follows:

1. There is a lack of understanding of what is meant by "Industrial Instruments."
2. There is a wide difference of opinion regarding the courses in which this subject should be taught.
3. There is a difference of opinion regarding the importance of the subject.
4. There is a desire for better preparation by instructors.
5. There is a lack of appreciation for the importance of the subject.

It is concluded that a basic course in "Industrial Instrumentation" should be available at least to all chemical and mechanical engineers. If there is any question regarding which course this subject should be introduced into chemical engineering should have first consideration.

378. Johnson, Charles A., "Coordinating Calculus Instruction in the Engineering Program." Jour. Eng. Educ. 41, 537-41 (May 1951).

A brief study at the University of Kansas brought several facts to light:

1. The objectives of calculus ought to be different for different branches of engineering.
2. If calculus is not used in follow-up courses, the student's facility deteriorates rapidly.
3. Civil and architectural engineers performed poorly, indicating that success in these fields does not depend on receiving the same amount of calculus as others.

379. Monteith, A. C., "Engineering -- Its Future." Elec. Eng. 70, 758-61 (Sept. 1951).

The vice president of Westinghouse Electric Corporation states that graduate credit is not a necessity in most cases for an engineer, but rather an incentive. The need for self-betterment among engineers is great as well as the need for constant, intensive reading and study in the broad professional field.

380. Sawyer, Herbert A., "Humanities for Engineering Students." Jour. Higher Educ. 22, 470-5 (Sept. 1951).

The University of Alabama program of humanities for engineers is outlined. The program is parallel to the program of engineering.

381. Shanks, M. E., "Mathematics for Engineers." Jour. Eng. Educ. 41, 308-10 (Jan. 1951).

Since a large proportion of engineers is not benefited by mathematics beyond elementary calculus, students training for design, production or sales should have the option of receiving an abbreviated course in the sophomore year.

382. Simpson, W. M., "Developing Creative Ability." Machine Design 23, 225-6, 228 (Sept. 1951).

Creative ability is best developed from a background in fundamentals. The learning of facts will not provide it.

383. Thuesen, H. G., "Engineering Economy -- What It Is and Its Place in Engineering Curricula." Jour. Eng. Educ. 41, 533-6 (May 1951).

Pointing to the desirability of cost-consciousness in engineering graduates, the author proposes that engineering economy be an elective course for juniors or seniors.

384. Weil, Joseph, "Building an Engineering Curriculum." Jour. Eng. Educ. 41, 578-82 (June 1951).

The principles which should guide curriculum-building are discussed in general terms. The author, dean of engineering at the University of Florida, sets forth these basic tenets:

1. The graduate of a four-year curriculum should be able to perform successfully in his field and to qualify for professional registration.
2. The graduate should be able to profit from literature and philosophy and should be able to function as a citizen.
3. The graduate curriculum is the special strength of the engineering graduate. A thesis is probably appropriate for all graduates.
4. Electives should be available.
5. Frequent study and revision of the curriculum is desirable.
6. The curriculum should contribute to the student's consciousness of his ethical and professional responsibilities.

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385. Anonymous, "Engineering Curricula Accredited by ECPD as of Oct. 28, 1949." Elec. Eng. 69, 179-80 (Feb. 1950).

386. Anonymous, "Four Year Program Favored at M. I. T." Eng. News-Record 148, 38 (Dec. 7, 1950).

An M.I.T. faculty committee recommends continuance of the four-year curriculum and increased emphasis on science and humanities. Engineering should not follow the lines of law or medicine.

The objectives of the undergraduate program should be general, rather than accumulation of education.

387. Anonymous, "Liberal Arts, Engineering." Eng. News-Record 145, 50 (Aug. 10, 1950).

The "three-two" plans of Case Institute of Technology and Rensselaer Polytechnic Institute, in cooperation with liberal arts colleges, are announced.

388. Anonymous, "What Is ECPD?" Mech. Eng. 72, 400-2 (May 1950).

389. Davis, Jess H., "Trends in Engineering Education." Tappi 33, 52A-53A (Feb. 1950).

This is a review by the president of Clarkson College.

390. Doherty, Robert E., "Comments on 'Differentiating Characteristics of an Engineering Curriculum.'" Jour. Eng. Educ. 40, 442-5 (April 1950).

The author criticizes the statement adopted by the ECPD Committee on Engineering Schools (Jour. Eng. Educ. 40, 291-4, Jan. 1950). The criticism includes four objections: (1) "ability to design" is not the only distinguishing function of the engineer; (2) the "design" criterion is violated by adding other functions (construction, etc.) in the original statement; (3) design courses are not what is needed but that is the implication; (4) the importance of flexibility is overlooked.

391. Drake, G. G., "The Humanities in the Technological School." Jour. Higher Educ. 21, 253-9 (May 1950).

The importance of humanities to engineering education is discussed. A program is suggested.

392. Fairman, J. F., "Is Engineering a Profession?" Elec. Eng. 69, 579-82 (July 1950).

A profession requires its practitioners be educated, involves mental rather than manual labor, implies scholarship and ministers to the populace.

Engineers would be better citizens if they underwent longer, broader more rigorous training. Engineers need to be able to talk more effectively on matters of public welfare and take more interest in public affairs.

393. Glennan, T. Keith, "Human Relations in Engineering Education." Jour. Eng. Educ. 40, 411-6 (April 1950).

The teaching of human relations to engineering students is in the experimental stage. The most profitable experiment seems to be concurrent training in humanistic-social studies and engineering.

394. Glennan, T. Keith, "The Interrelation of Technical Education and Industry." Mech. Eng. 71, 1028-30 (1950).

Engineers are technologically prepared for industry, but are not prepared in other ways: moral values, human relations, communications skills.

395. Griffith, James R., "Engineering Curricula." Mech. Eng. 72, 508-9 (June 1950).

Basic engineering science must not be crowded out of the curriculum by specialized courses. The new (1948) general engineering curriculum of the University of Portland, Oregon, is outlined.

396. Hammond, H. P., "Contributions of the Liberal Arts to the Training of Engineers." Jour. Higher Educ. 21, 189-93 (April 1950).
397. Hollister, S. C., "Differentiating Characteristics of the Engineering Curriculum." Elec. Eng. 69, 99-101 (Feb. 1950).

In differentiating the engineering curriculum from other curricula, one must understand the differing characteristics of an engineer's work. Generally, all engineering curricula can be divided into five basic sections:

1. Basic science (mathematics, physics, chemistry, biology)
2. Applied science (mechanics, thermodynamics, fluid mechanics, aerodynamics, geology, properties of engineering materials, etc.)
3. Applied engineering courses (internal combustion engines, machine design, structures, industrial electronics, plant layout, etc.)
4. Administrative and managerial (cost control, quality control, industrial organization, labor relations, etc.)
5. General (liberal courses for general background).

398. Hollister, S. C., "Differentiating Characteristics of an Engineering Curriculum." Jour. Eng. Educ. 40, 291-4 (Jan. 1950).

The differences between engineering and science curricula are discussed. The engineering curriculum furnishes the background for the ability to analyze and synthesize which is essential to design. This statement has been adopted by the ECPD Committee on Engineering Schools.

399. Hollister, S. C., "Differentiating Characteristics of an Engineering Curriculum." Mech. Eng. 72, 122-3 (Feb. 1950).
400. Kingdom, K. H., "Engineering Education for Atomic-Energy Development." Gen. Elec. Rev. 53, 7-13 (Feb. 1950).

Most of the people needed in atomic power work in the future will need special training in current engineering and in physical, chemical and metallurgical skills. About ten per cent of these people will need up-to-date knowledge of fission and neutron physics. Most of this knowledge has to be obtained on the job now due to security restrictions, unavailability of nuclear reactors and excessively expensive materials and equipment. The largest portion of the work force will consist of chemists, chemical engineers and health physicists who again will have to gain the bulk of their knowledge on the job.

401. Kirkpatrick, Sidney D., "Postgraduate Training for Leadership." Machine Design 22, 226, 228, 230 (June 1950).

Ideas for introducing liberal material into the curriculum are reviewed.

402. LeClair, T. G., "Is the Engineering Graduate Educated?" Elec. Eng. 69, 951-2 (Nov. 1950).

"If an engineer is to become a reasonably well-rounded man and not merely a highly specialized technician, he must have a knowledge of the arts and sciences, he must be able to express himself, and he must learn how to think in general," say T. G. LeClair, president of AIEE. The engineer at the end of four years of college is not completely educated and not competent in a specialty. A professional society can help fill the gaps in education after graduation and selection of a specialty.

403. Lee, E. S., "An Engineer Looks at Mathematics Teaching." Elec. Eng. 69, 492-5 (June 1950).

This article is a speech by past AIEE president Everett S. Lee. Mathematics is the tool through which even the simplest daily routines and jobs are carried out. The actual mathematical function takes a back seat to the actual phenomena, but properly used, it can explain the how and why of the phenomena. Often a keen understanding of mathematics is necessary to produce the desired result.

404. Lewis, Warren K., chairman, "M.I.T. Educational Survey." Tech. Rev. 53, 30-3, 60, 62-3 (Nov. 1950).

The Committee on Educational Survey, after three years of study, has produced the report which is summarized here.

The committee adopts as basic policy the principle that the objectives of undergraduate study are general rather than the accumulation of information. Recommendations include:

1. Reducing detailed course content and emphasizing fundamental principles.
2. Fortification of humanities and social sciences.
3. Allowance for individual student aptitudes.

The concept of an education built along the lines of law or medical education is rejected, as is the suggestion of a five- or six-year curriculum.

A four-year curriculum, after which the graduate may or may not do graduate work, is cited as the best alternative for M.I.T.

The humanities program, as proposed by the committee, provides a two-year core curriculum followed by an upper-class elective sequence.

405. Linville, T. M. and McEachron, K. B., Jr., "Design Problems for Engineering Education." Elec. Eng. 69, 29-33 (Jan. 1950).

Due to the more and more specialized training received in college, the engineering graduate finds it increasingly difficult to solve simple problems involving more than a single field. Industry is becoming more aware of a need for men with a more comprehensive knowledge.

Engineering courses, commonly given to seniors, should emphasize the breadth of practical engineering problems.

"We must have engineers who have the knowledge, imagination, and vision required to produce new products and devices; knowledge, imagination, and vision which is not limited to anyone particular kind of engineering but which ranges over the whole field."

406. Osborne, Harold S., "Engineering Education and the Requirements of Industry." Jour. Eng. Educ. 41, 199-205 (Dec. 1950).

Engineers need less training in specialized techniques, and more in economy, elementary statistics, report preparation, human relations, and planning.

407. Pletta, D. H., "A New Approach to the Doctor's Degree for Engineers." Jour. Eng. Educ. 41, 161-5 (Nov. 1950).

Largely because of unfavorable public attitudes toward professional engineers, the author proposes a basic four-year curriculum, followed by two years of advanced study, and culminating in a one-year internship as requirements for the doctorate. This would reduce engineering Ph.D. requirements to seven years instead of the "equivalent of nine academic years" now required.

The basic curriculum, designed to avoid too early specialization, consists of 39 credits (quarter basis) of cultural subjects, 32 of physical science, 40 of mathematics (through differential equations and "advanced calculus"), and 109 credits of engineering.

The fifth year program, in this case for civil engineering, would include specialty subjects in transportation, sanitary engineering, surveying and mapping, construction, and design. The sixth year would be highly specialized.

A seventh year of broad internship would qualify the graduate for the doctorate and a professional license. The public pays little heed to professional licenses, but combined with the doctorate, the engineering profession would stand much higher because of them.

408. Saville, Thorndike, "Engineering Education in a Changing World." Jour. Eng. Educ. 41, 4-10 (Sept. 1950).

The retiring president of ASEE surveys the state of engineering curricula. On the whole, they remain conventional and compartmentalized.

A student should not be forced to choose his branch of engineering so early. The author presents his suggestion for a unified three-year program for all college students, which would be capped by a fourth year for earning an undesignated Bachelor of Engineering degree, and a fifth year for earning a designated degree.

409. Schwieger, Albert J., "Survey of the Teaching of Economics and Related Subjects to Engineers." Jour. Eng. Educ. 41, 231-4 (Dec. 1950).

No uniformity of curricular patterns in the fields of economics, industrial-management type courses, and psychology was observed among 43 schools.

410. Sherwood, Thomas K., "The Relation of Research to Engineering Education." Chem. Eng. News 28, 456-8 (Feb. 13, 1950).

The most important feature of university research is that it be of such a nature as to permit student participation. Students who intend to enter research should undertake research problems and should write theses, even as undergraduates.

411. Taggart, Arthur F., "New Way of Educating Engineers." Mining Eng. 187, 460-2 (April 1950).

The author presents a five point plan for the education of engineers:

1. Human relations -- elementary biology, humanities, political and economic history and English.
2. Science -- physics, chemistry and mathematics.
3. Basic Engineering -- strength of materials, fluid flow, electrical machinery, heat transfer, etc.
4. Specialty subjects -- limited to ten semester credits in the senior year.
5. Graduate work -- reserved only for those engineers destined for research.

In a statement accompanying the article, Curtis L. Wilson avers that this curriculum would be turned down by the ECPD Committee on Engineering Schools. He adds that it is not engineering.

Professor Taggart is with the Columbia University School of Mines.

1949

412. Freund, C. J., "Engineering Education and Freedom from Fear." Jour. Eng. Educ. 40, 11-17 (Sept. 1949).

The retiring president of ASEE underlines the moral obligations of engineers and scientists, and the paucity of their moral contributions to date. He concludes that engineers should be taught religion, ethics, and philosophy.

413. Killian, James R., Jr., "Science and the Humanities." Tech. Rev. 52, 33-5 (Nov. 1949).

The president of M.I.T. underlines the complementary nature of general and specialized knowledge.

414. Ledgerwood, L. W., Jr., "Engineers Need Broader Training." World Oil 129, 50-2 (Nov. 1949).

415. Prentice, D. B., "ECPD Accrediting Program." Elec. Eng. 68, 959-60 (Nov. 1949)

The Engineer's Council for Professional Development, formed in 1932, has as its end "the enhancement of the professional status of the engineer. It aims to coordinate and promote efforts toward higher standards of education." The following are basic principles of accreditation:

1. Recognition of curricula rather than institutions.
2. Consideration of undergraduate curricula only.
3. Inspection of curricula only on invitation from the institution.
4. Avoidance of rigid standards, to prevent standardization and to encourage experimentation.
5. Accrediting only after inspection by competent examiners who will consider qualitative as well as quantitative factors.
6. Review of examiner's reports and recommendations by the inspection committee, the national committee and finally the Council itself.
7. Publication of list of approved curricula, all on the same basis, with no reference to other unapproved curricula.

Approximately 65 per cent of the engineering curricula in the United States have been fully accredited.

1948

416. Girvin, Harvey F., A Historical Appraisal of Mechanics. New York: International Textbook Co. (1948). 228 pp.

1930

417. Wickenden, W. E., director and Hammond, H. P., associate director, Report of the Investigation of Engineering Education 1923-1929. Pittsburgh, Pa.: Society for the Promotion of Engineering Education. (1930). 1320 pp. (2 vol.).

1912

418. Anonymous, Bulletin of the Massachusetts Institute of Technology, Vol. 48, No. 1, (1912), p. 33.
419. Anonymous, Bulletin of the Massachusetts Institute of Technology, Vol. 48, No. 1, (1912), p. 38.
420. Anonymous, Bulletin of the Massachusetts Institute of Technology, Vol. 48, No. 1, (1912), p. 88.

1908

421. Anonymous, Bulletin of the Georgia School of Technology, Vol. 6, No. 3, (1908-9), p. 75.

MECHANICAL ENGINEERING

1960

422. Buhl, Harold R., "All You Need Is a Handbook." Jour. Eng. Educ. 50, 312-5 (Jan. 1960).

The goal of an engineering education is to attain the ability to solve problems, according to the author, who is a mechanical engineer. Since it is no longer possible to expose the student to all available engineering knowledge, he should be exposed to an atmosphere in which the method of solution, rather than the answer, is emphasized.

To this end, curricula should be examined to determine if all courses are fundamental. Course material must be conducive to analysis and, finally, synthesis of new solutions.

1959

423. Landis, F., chairman, "Survey of Undergraduate Heat Transfer Teaching for Mechanical Engineers." Jour. Eng. Educ. 49, 977-8 (June 1959).
424. Modrey, Joseph, "The Future of Machine Design." Jour. Eng. Educ. 49, 355 (Jan. 1959).
425. Pefley, R. K., "Experience in Teaching Thermodynamics and Fluid Mechanics as an Integrated Course." Jour. Eng. Educ. 50, 77-80 (Oct. 1959).
426. Wulff, J., and Taylor, H. F., "A Materials Engineering Course of Engineering Science Calibre." Jour. Eng. Educ. 49, 707-12 (April 1959).

Attempts at three schools to present materials from a more fundamental approach are described and discussed. It is concluded examples should indicate earnest efforts are being made to teach materials as an engineering science.

1958

427. Astill, Kenneth N., "The New Look in Heat Power: Undergraduate Study." Jour. Eng. Educ. 48, 277-82 (Jan. 1958).
428. Dreifke, Gerald E., Hougen, Joel O., and Williams, Theodore J., "An Industrial Plan for Systems Engineering Education." Jour. Eng. Educ. 48, 760-3 (May 1958).
429. Keenan, J. H., Fay, J. A., and Hatsopoulos, G. N., "Education in Mechanical Engineering for Power Production." Paper No. 58-PWR-10, presented at Am. Soc. Mech. Engrs. meeting, Sept. 28 - Oct. 1, 1958. 4 pp.

Modern developments in power can be exploited only by engineers who have a broad scientific training. A suitable undergraduate mechanical engineering program is outlined.

430. Thal-Larsen, Herman, "A Course of Instruction in Systems Engineering." Jour. Eng. Educ. 48, 742-54 (May 1958).

1957

431. Arms, H. S., "American System of Education and Training of Mechanical Engineers." Proc. Inst. Mech. Engrs. 171, 215-9 (1957).

A British engineer reviews American engineering education. Particular attention is given to the trend toward engineering science in the curriculum.

The author singles out these reasons for the present-day interest in engineering curricula:

1. Rivalry with the U.S.S.R.
2. The success of scientists in performing engineering work during the war years.
3. The self-analytical attitude of the American engineering profession since its early days.

No trends in graduate education are noted.

432. Howe, Everett D., "Trends in Laboratory Instruction for Mechanical Engineering." Jour. Eng. Educ. 47, 565-7 (Mar. 1957).

433. Potter, J. H., "Graduate Study in Mechanical Engineering." Mech. Eng. 79, 157-60 (Feb. 1957).

Graduate study in mechanical engineering is reviewed. Mechanical engineering is compared with other branches, with regard to the number of graduate degrees granted.

434. Zylstra, L. B., "Voice from the Other Side of the Tracks." Jour. Eng. Educ. 47, 543-7 (Mar. 1957).

Production methods courses, far from being trade-school courses, have an importance in mechanical and industrial engineering curricula over and above the proportion of time given them.

1956

435. Salvesson, M. E., "Suggestions for Graduate Study in Operations Research and Systems Engineering." Jour. Eng. Educ. 47, 211-22 (Nov. 1956).

1954

436. Bollay, William, "Graduate Education in Engineering." Jour. Eng. Educ. 44, 455-60 (April 1954).

The primary emphasis in graduate study should be on engineering sciences. A suggested graduate program for mechanical and aeronautical engineers is the following:

Applied mathematics	2 years
Fluid mechanics	2
Structures and theory of elasticity	2
Dynamics	1

Thermodynamics and heat transfer	1 year
Modern physics (survey)	1
Applied electronics	1

This is a Ph.D. program, which would also include a research-based thesis and concurrent courses in a physical science.

437. Hutchisson, Elmer, "Engineering Curricula -- Then and Now." Jour. Eng. Educ. 44, 584-9 (June 1954).

Today's curriculum differs from that of 25 years ago in being much more concentrated with emphasis on fundamentals. There is also more emphasis on humanistic-social studies and communicative skills. Today's curriculum in mechanical engineering is typically 36 hours of basic science, 35 of basic engineering, 42 of applied engineering, 8 of skills, and 34 hours of humanistic-social studies.

438. Sanders, Jennings B., General and Liberal Educational Content of Professional Curricula. Engineering with Special Reference to Mechanical Engineering. Pamphlet No. 114, Office of Education, U. S. Department of Health, Education and Welfare. Washington: U. S. Government Printing Office (1954). 31 pp.

The principal concern of this bulletin is the present-day curriculum. A detailed evaluation of mechanical engineering curricula from the viewpoint of non-technical content is presented. The findings of this bulletin, appearing a year before the Final Report of the ASEE Committee on Evaluation of Engineering Education, strongly underlines the low fraction of humanistic-social studies in engineering curricula.

Only 9.5 per cent of the curriculum is liberal in nature. At best, when communication arts and free electives are included, the percentage is 17.8, even though electives are more likely to be technical subjects. Even in the lower figure the courses include economics, while history, languages and literature are less frequently required. Only in private colleges having religious affiliation is there significant concern with ethics, philosophy and religion, and even this is doctrinal.

The two major portions of the curriculum -- liberal and technical -- do develop in parallel sequences, as recommended in earlier ASEE reports.

One very large area of knowledge -- biological science -- is almost completely absent from mechanical engineering curricula.

Much of the bulletin is given to review. There is first of all a historical review of curriculum studies. Salient individual opinions are also reviewed. Then the various schools of thought regarding curricular plans (especially with regard to length of curriculum) and the place of liberal studies are summarized.

Another finding of the bulletin is that "the most striking thing about the engineering curriculum" is its great weight. The course work is noticeably heavier than that of liberal arts colleges.

The analysis includes 112 four-year and 4 five-year curricula, plus 9 cooperative curricula and 2 which fall into no other category. Mechanical engineering is chosen for evaluation because it represents the largest number of engineering degrees being granted.

439. Wellman, B. Leighton, "An Engineering Curriculum Designed for Today's Student." Jour. Eng. Educ. 44, 469-75 (April 1954).

A professor of mechanical engineering outlines a suggested modern curriculum. The first two years concentrate on mathematics, materials and processes, energy in its various forms, graphics, and verbal training. The second two years begin with strong emphasis on testing and analysis, deal strongly also with design and synthesis, and introduce the student to "living", personnel, and assorted specialty subjects.

1953

440. Bailey, Neil P., "What Are Contemporary Demands on Engineering Curricula? Mechanical Engineering." Jour. Eng. Educ. 43, 303-6 (Jan. 1953).

Emphasis on science and mathematics has disadvantages when applied to a mechanical engineering curriculum. An engineer must solve problems, and to strip his training of departmental, specialized courses is to endanger his ability to apply his knowledge.

To date, the efforts to train engineers for the everyday business relations which they will experience have been a failure. Future programs must equip engineers for a broad outlook and for successful relations with other people.

441. Besio, Charles A., and Blum, Harold A., "Unit Operations for Mechanical Engineers." Jour. Eng. Educ. 43, 469-71 (April 1953).

Because many mechanical engineers enter the process industries, the authors (both M.E.'s) recommend a unit operations option for this branch of engineering.

442. Wolpert, N. N., "Air Conditioning, Refrigeration, and Heating and Ventilating Courses Offered by Colleges." Heating and Ventilation 50, 87-90 (Aug. 1953), 99-102 (Sept. 1953).

1952

443. Hardgrove, Tom, "Plant Engineering Goes to College." Plant Eng. 6, 80-1 (Mar. 1952).

A curriculum in plant engineering is outlined which closely parallels a mechanical engineering curriculum. Because of this, and because of (1) lack of appeal to entering freshmen and (2) limited job placement for the plant engineering graduate, it is recommended that plant engineering be an M.E. option.

1951

444. Bailey, Neil P., "Engineering Physics." Mech. Eng. 73, 819-20 (Oct. 1951).

Such fields as mechanics and thermodynamics should be taught exclusively in the engineering science courses of the student's department. Physics, freed from this burden of duplication, could be taught from the modern standpoint alone.

445. Eisenberg, Richard F., "Metallurgy in the Mechanical Engineering Curriculum." Jour. Eng. Educ. 41, 387-8 (Mar. 1951).

Mechanical engineers need a knowledge of metals only less than metallurgists. A sequence of two three-hour courses is proposed, the first a lecture course in physical metallurgy, the second a lecture-laboratory course in applied metallurgy.

446. Heuschkel, J., "Welding in American Engineering Education." Welding Jour. 30, 435-46 (1951).

447. Kellogg, D. S., "Are Engineering Graduates Prepared for Their Jobs?" Mech. Eng. 73, 572-5 (July 1951).

The most important attribute of the engineer is his ability to "get things done." He should develop in college those traits -- ability to organize his thinking, to work with others, and to communicate with others -- which are most important to industry.

A new sequence of courses is needed. A committee of industrialists could review present courses for "adequacy and method of approach" and formulate the needed new courses in "Industrial Training."

To make room for these courses, less essential, supplementary material, designed to "round out" the student, could be dropped. If the normal academic year is not long enough, it should be lengthened.

Existing courses should be reviewed primarily from the viewpoint of how well they prepare the student for industry's problems. The new course series, consisting of about one hour per week for two years, should concentrate heavily on examples drawn from industry.

The author is an engineering executive.

448. LaJoy, Millard H., "Instrumentation and Automatic Control Course for Mechanical Engineers." Instruments 24, 406-7 (April 1951).

The Mechanical Engineering Department of the University of Minnesota feels that it is the school's responsibility to train engineering students in instrumentation and automatic control. The purpose of this article is to outline the setting up and teaching of an Instrumentation and Automatic Control course. A brief eleven-week outline of the course is given:

1. Domestic control circuits.
2. Terminology.
3. Mathematics of control.
4. Principle of operation and circuit analysis of pneumatic-type controllers.
5. Principle of operation and circuit analysis of hydraulic-type controllers.
6. Principle of operation and circuit analysis of electric-type controllers.
7. Lag coefficients and process time constants.
8. Process analysis of single and two capacity systems.
9. Controller settings as related to process analysis.
10. Final control elements.
11. Typical applications of automatic controls.

The laboratory course includes twelve experiments on domestic control circuits and nine experiments on industrial instruments and controls.

449. Slaymaker, R. R., and Wright, D. K., Jr., "Graduate Work in Machine Design." Jour. Eng. Educ. 42, 164-9 (Nov. 1951).

The mechanical engineer who masters in machine design is a practical person who uses rather than discovers technical facts. For this reason, additional course work may be preferable to a thesis. A typical M.S. program would include: vibration problems, advanced strength of materials, kinematics and dynamics of machines, problems in machine design, applied elasticity, experimental stress analysis, and either thesis or about eight credit hours of course work.

450. Taylor, Howard F., "Graduate Studies for the Foundry." Am. Foundryman 20, 54-7 (Aug. 1951).

The foundry program at M.I.T., based upon graduate or senior-year specialization, is discussed.

1950

451. Juran, J. M., "Engineer as Manager." Mech. Eng. 72, 300-2, 320 (1950).

The engineer is not trained for management, because he is not trained in dealing with people. Humanities are a step in the right direction, but very little more can be done in college toward training engineers for management. Graduate study is some help.

For the most part, however, training for management must be performed in industry itself, which is the only real laboratory for this purpose.

1928

452. Turnbull, Archibald Douglas, John Stevens, An American Record. New York: American Society of Mechanical Engineers (1928). 545 pp.

OTHER

1960

453. Moore, Harry D., "A Modern Approach to Teaching Manufacturing Processes." Jour. Eng. Educ. 50, 316-20 (Jan. 1960).

1959

454. Armsby, Henry H., "An Analysis of 'Other' Engineering Curricula." Jour. Eng. Educ. 49, 467-9 (Feb. 1959).

Minor branches of engineering, for which degrees are offered at various schools, are listed. Schools are not listed. The report is for fall 1957.

455. Clark, George B., "High-Level Energy Transfer Processes in Mining Engineering." Jour. Eng. Educ. 49, 600-5 (Mar. 1959).

456. Degroff, Harold, "An Undergraduate Course in Mechanics of Materials for the Aeronautical Engineering Student." Jour. Eng. Educ. 49, 360-5 (Jan. 1959).

457. Hoelscher, H. E., "Chemical Engineering Education at Johns Hopkins." Jour. Eng. Educ. 49, 791-6 (May 1959).

In 1952 Johns Hopkins adopted a chemical engineering curriculum based on the "engineering science" concept. In this article the curriculum is outlined in detail, and the effect of the program on its graduates is discussed.

The author observes that all students seem to have benefited from the program, but he notes that its major limitation is the necessity for a high faculty-student ratio.

458. Nicholas, John E., "The Impact of Nuclear Physics on Agricultural Engineering." Jour. Eng. Educ. 49, 457-61 (Feb. 1959).

Uses of radiation and radioisotopes in agriculture and metabolic studies are mentioned. The author asserts that future curricula will have to include some of this technology.

459. Packie, John W., and Smith, Charles W., "A Petroleum Industry Look at the Chemical Engineer's Curriculum." Jour. Eng. Educ. 49, 691-8 (April 1959).

Chemical engineering graduates are rated strong in chemical engineering calculation principles and in professional ethics. Graduates were weakest in communication and in judgment.

Other recommendations for curricular improvement include:

1. Course in statistics.
2. Familiarization with computers.
3. Integration of physical chemistry and thermodynamics.

4. Reduction of quantitative and qualitative chemistry courses.
 5. Reduction of drawing.
 6. Increased emphasis on type of problems encountered in industry.
460. Pask, Joseph A., "Education for the New Era of High Temperature Technology: The Challenge to Ceramic Engineering Education." Jour. Eng. Educ. 49, 328-31 (Jan. 1959).

The rapid advance of ceramic science has posed to ceramic engineers the problem of inserting more education into the same available time. The author calls for a strongly scientific approach to the study of materials, and a unification of production processes into a "unit operations" approach like that used by chemical engineers.

461. Peters, Max S., "Planned Technical Electives for Better Engineering Education." Jour. Eng. Educ. 49, 713-7 (April 1959).

A chemical engineering educator scores the rigidity of engineering curricula. Courses of a broadening nature are most desirable as electives, with courses in advanced basic science (e.g., physics) and specialized courses in the major subject next.

A table of technical electives, rated according to value, is presented for the major fields of engineering study. Particular recommendations are (1) chemical engineering for non-chemical engineers and (2) engineering economics.

462. Reethof, G., "Control Technology as Unifying Tool in Engineering Education." Paper No. 58-A-199 presented at Am. Soc. Mech. Engrs. meeting, Nov. 30 - Dec. 5, 1958. 4 pp.

463. Schroeder, E. W., "The Developing Ph.D. Program in Agricultural Engineering." Jour. Eng. Educ. 49, 806-9 (May 1959).

464. Schmidt, A. X., "What Is the Current B. Ch.E. Curriculum?" Jour. Eng. Educ. 50, 65-76 (Oct. 1959).

The 1956-57 curricula of 87 U.S. chemical engineering schools are examined statistically. All known accredited schools are represented.

The study demonstrates the diverseness of chemical engineering curricula among accredited schools. Net credits (adjusted for non-standard courses) range from 118 to 160, chemical engineering credits from 23 to 45. There emerges a "hard core" curriculum of subjects offered in at least 90% of accredited institutions, and accounting for 72% of average net credit.

Averages are examined in the light of the ASEE recommendation that a fifth of the curriculum be devoted to humanities and social studies. About 10% of the current curricula conform closely to the recommendation. Most others could, by eliminating courses better suited to high school, increase their "cultural" content.

The current curriculum is shown to be weak in mathematics. Less than half include differential equations.

465. Stewart, Warren E., "The Wisconsin Course in Transport Phenomena." Jour. Eng. Educ. 49, 593-9 (Mar. 1959).

A basic chemical engineering course in transport phenomena is intended to impart fundamental principles, leaving specialization to later courses.

1958

466. Liebeskind, Herbert, "The AEC-NSF-ASEE Nuclear Institutes." Jour. Eng. Educ. 48, 611-14 (April 1958).

A professor of chemistry discusses the benefit he derived from the 1956 and 1957 summer institutes on nuclear engineering. All who attended agreed that, although nuclear science should be incorporated into present curricula, there was no justification for an undergraduate nuclear engineering curriculum.

467. Linsky, Chester, "Professional Education for Automation Engineers." Tool Engr. 40, 113-18 (April 1958).

Automation engineering has emerged as a new branch. In this article a curriculum is proposed which includes: 13 semester-hours of mathematics, 12 hours of chemistry and physics, 30 hours of English and social science, and the rest principally engineering art, a total of 149 hours.

468. Philbrook, W. O., "Education in Process Metallurgy." Jour. Metals 10, 679-81 (1958).

The "unit process" or "unit operations" approach is discussed as a possible system for teaching process metallurgy. This embodies the plan for studying a body of basic engineering principles and a set of unit operations and processes that occur in most important engineering processes.

The foundations for teaching by this system are mathematics, physics, and chemistry. Physical chemistry is most important.

469. Power, Harry H., "So You Want to Be a Petroleum Engineer?" Petrol. Engr. 30, E3-5 (Jan. 1958).

The ideal petroleum engineering curriculum contains perhaps 190 semester hours of courses, requiring eleven semesters for completion. Included are 30 hours of geology, 16 of mathematics, 34 of petroleum engineering, 38 of assorted engineering, 35 of science, and 31 hours of English and "general."

A "primary motive" of graduate study is to obtain emphasis on basic science which was lacking in undergraduate work.

470. Weikart, John, "What Does Industry Want in Engineering Graduates?" Jour. Eng. Educ. 48, 376-80 (Feb. 1958).

Industry wants a chemical engineer well grounded in fundamentals. Mathematics was prominently mentioned, after chemical engineering subjects. Also cited was ability to communicate.

1957

471. Davis, W. Kenneth, "AEC Educational Assistance to Engineering Colleges." Jour. Eng. Educ. 48, 193-200 (Dec. 1957).

The present fragmentation of engineering argues against establishing a new field of nuclear engineering. Nevertheless the nuclear field needs engineers for its specialized work. The AEC is interested in assisting schools in their nuclear programs.

472. Dryden, Charles E., "Summary of Survey on College Programs in Nuclear Engineering." Jour. Eng. Educ. 47, 470-1 (Jan. 1957).

In the school year 1955-56 there were 73 schools offering nuclear subjects, a total of 269 courses. Chemical engineering was most active in the field, followed by physics, nuclear engineering and mechanical engineering.

473. Gunder, Dwight F., "Remarks on the Integration of Subject Matter." Jour. Eng. Educ. 48, 238-40 (Dec. 1957).

An experiment was performed in integrating mathematics, physics, mechanics and two minor courses in the chemical engineering curriculum into one course (two years) in engineering fundamentals, with mathematics and physics (one year each) reserved for the junior or senior year. The experiment was conducted at Cornell.

Mathematics was introduced into the engineering fundamentals course as need arose. The physical basis of mathematical procedures was emphasized.

With this approach, students are able to enter many advanced courses a year sooner than normally. Additional mathematics and physics are taken by the student after he has some background and has become aware of their value.

474. Lewis, H. Clay, "The Cost of a Practice School for Chemical Engineering." Jour. Eng. Educ. 47, 827-35 (June 1957).

475. Madden, R. B., "Undergraduate Education of Naval Engineers -- U.S. Naval Academy." Jour. Am. Soc. Naval Engrs. 69, 7-28 (Feb. 1957).

476. Stebbins, Dean W., "Development of Operations Research." Jour. Eng. Educ. 47, 836-8 (June 1957).

The educational background required for operations analysis is summarized.

477. Stehling, K. R., "Education for Missile Age." Missiles and Rockets 2, 50-100 (Jan. 1957).

The missile engineer of the future will need a thorough grounding in only the fundamentals of physics, mathematics and chemistry. It is the author's opinion that today's engineer is "overtrained and only partly educated."

1956

478. Aries, Robert S., and Cziner, Rudolph M., "The Integration of Economy Concepts in the Chemical Engineering Curriculum." Jour. Eng. Educ. 46, 446-52 (Jan. 1956).

479. Barish, N. N., "New Undergraduate Curriculum in Industrial Engineering." Jour. Ind. Eng. 7, 226-9 (1956).

An experimental curriculum which emphasizes breadth of coverage in science and mathematics is outlined completely, including the number of credit hours associated with each course. Elective options are included.

480. Elgin, Joseph C., "Engineering and Chemical Engineering of the Future." Chem. Eng. Prog. 52, 8J-11J (Jan. 1956).

The author finds himself in agreement with the ideas outlined by R. R. White (Chem. Eng. Prog. 51, 379-81 (Aug. 1955))

481. Guerrero, E. T., and Langenheim, R. L., "An Idealistic Curriculum in Petroleum Production Engineering." Jour. Eng. Educ. 47, 304-9 (Dec. 1956).

The idealistic curriculum is compared with the present curriculum of Tulsa University. Seven other petroleum engineering curricula are also summarized.

1955

482. Carter, J. W., "Graduate Study in Aeronautic Engineering." Aero. Eng. Rev. 14, 28-30, 34 (Sept. 1955).

The aircraft industry generally feels that an engineer well-grounded in fundamentals will be ready for any assignment. In aeronautical engineering, the curriculum should stress mathematics and mechanics.

In this article, subjects for inclusion in the Master's and Ph.D. programs are listed. It is mentioned that engineers in the industry believe liberal studies have a place in graduate education.

483. Hawkins, G. A., "The Role of the Colleges in Nuclear Engineering Education." Jour. Eng. Educ. 46, 123-6 (Oct. 1955).

The college can meet the nuclear industry's needs for engineers in three ways:

1. Curricula in nuclear engineering.
2. Providing flexibility in existing programs.
3. Adding nuclear topics to existing required courses.

Graduate study in nuclear engineering subjects should be offered. The recommendations of the ASEE Committee on Evaluation of Engineering Education are well suited for study in this field.

484. Hayward, B. W., "Textile Education, Graduate and Undergraduate." Textile Res. Jour. 25, 603-8 (1955).

485. McKee, Robert E., "Training Tomorrow's Tool Engineers." Tool Engr. 35, 69-72 (July 1955).

More tool and production engineering courses are needed in engineering curricula. A mechanical engineering curriculum, suitably altered at the junior and senior level, might become a tool engineering option.

486. Schuhmann, R., Jr., "Integration of Metallurgical Engineering Education." Jour. Metals 7, 647-50 (May 1955).

It has been proposed that undergraduate metallurgical engineering curricula should be built around four principal scientific themes: thermodynamics, structure, mechanics, and rate processes.

Each of these themes are discussed and a complete four-year course is outlined although the author emphasizes that no curriculum is cut and dried because of the recognized fact that "both teacher and student must continually reorganize their knowledge and continually replace their own generalizations."

487. Tiller, F. M., "Thermodynamics for Chemical Engineers." Jour. Eng. Educ. 45, 658-9 (April 1955).

488. White, Robert R., "Chemical Engineering and Science Engineering." Chem. Eng. Prog. 51, 379-81 (Aug. 1955).

The new Science Engineering program of the University of Michigan is compared with the chemical engineering program. The new program begins physical chemistry and calculus in the freshman year, with heavy emphasis on engineering science in succeeding years. Electives are offered in mathematics, liberal studies, and professional courses including chemical engineering.

1954

489. Draper, C. S., "Teaching Instrument Engineering." Jour. Instr. Soc. Amer. 1, 13-7 (Oct. 1954).

Suggested required courses for instrumentation engineers are divided into four categories:

1. Background courses in humanities and social sciences.
2. Background courses in mathematics and sciences.
3. Background courses in engineering.
4. Professional courses in instrument engineering.

The humanities requirements should make up one-fourth of a four-year curriculum.

490. Forrester, J. D., "An Analysis of Mineral Industry Engineering Curricula." Jour. Eng. Educ. 44, 332-9 (Jan. 1954).

Three branches of mineral engineering are recognized: (1) mineral exploration engineering, (2) mineral production engineering, and (3) mineral process engineering. Curricula are outlined for each.

Mineral engineering compares with chemical engineering as follows:

	<u>Chemical Engineering</u>	<u>Mineral Engineering</u>
Basic sciences	45	31
Engineering science - service courses	20	17
Humanistic-social studies	15	15
Professional fundamentals	20	17
Electives	0	19

491. Hayward, B. W., et al., "Textile Education." Modern Textiles 35, 32-3, 42-3, 46, 49, 52, 54, 56, 59 (June 1954).
492. Mehl, Robert F., "The Nature of Education in Metallurgical Engineering." Jour. Metals 6, 728-33 (June 1954).

As a freshman and sophomore, the student is prepared mainly in the basic sciences. The real metallurgical engineering and science studies do not come until the last part of the junior year and the senior year. The author states that no one pattern is sacrosanct, since the same goal can be reached with different curricular patterns. A few of the basic principles of the curricular outline are discussed such as physical metallurgy, physical chemistry of metallurgy, and the social-humanistic courses.

493. Taylor, J. G., et al., "Texas Petroleum Engineering Schools." Oil Gas Jour. 53, 186-8, 190-1, 193-5, 198 (May 24, 1954).

Seven colleges in Texas offer degrees in petroleum engineering. This article describes them and discusses petroleum engineering curricula briefly.

1953

494. Brown, George Granger, "What Are Contemporary Demands on the Engineering Curricula? Chemical Engineering." Jour. Eng. Educ. 43, 307-11 (Jan. 1953).

A strong background in basic science, and practice in solving engineering problems, are needed by all chemical engineering graduates.

495. Emerson, Howard P., "A Mathematics Foundation for Industrial Engineering." Jour. Eng. Educ. 43, 472-5 (April 1953).

Higher mathematics, particularly statistics, is increasingly important to industrial engineers. Matrix algebra will also be more valuable as computers are used more and more. Two years of fundamental mathematics, more comprehensive than that currently offered, can provide the industrial engineer with the background he needs. Differential equations may not be among the necessary courses.

496. Holderman, K. L., Breneman, J. W., and Walker, Eric A., "The Echelons of Engineering Education." Jour. Eng. Educ. 44, 234-42 (Dec. 1953).

The Engineering Science curriculum of Penn State is outlined. The new curriculum is regarded as an "honors course."

497. Keyes, D. B., "History and Philosophy of Chemical Engineering Education." Chem. Eng. Prog. 49, 635-40 (1953).

In this article the types of courses needed in a chemical engineering curriculum are discussed at length. Specialized courses, it is noted, do not belong in the curriculum at the expense of broader education.

The only trend noted is the rising importance of chemical engineering economics.

498. Marston, George A., "Integrating the Activities of an Agricultural Engineering Department in a School of Engineering." Jour. Eng. Educ. 43, 570-2 (June 1953).
499. Smith, J. M., "Integration of Chemical Engineering Fundamentals." Jour. Eng. Educ. 43, 537-9 (May 1953).
500. Wilson, C. L., "What Are the Contemporary Demands on Engineering Curricula? Mining and Metallurgical Engineering." Jour. Eng. Educ. 43, 312-15 (Jan. 1953).
501. Winding, C. C., et al., "Forum on Education of Plastics Engineer." Jour. Soc. Plastics Engrs. 9, 18-21, 34 (Oct. 1953); 10, 20-1, 68-71, 90 (June 1954).

A survey in 1951 by S.P.E. reveals:

1. There are few schools offering required courses in high-polymers.
2. There are virtually no courses in high polymers offered outside of chemistry and chemical engineering departments.
3. Very few schools have laboratory processing or fabricating equipment.
4. Only one university has a program in high polymers that even approaches the one suggested by the S.P.E.

Due to the lack of plastics engineers in the pure sense, industry is interested in having other types of engineers such as chemical, mechanical, electrical, and aeronautical engineers, trained in the arts of plastics, in the order named. The demand for engineers trained in plastics currently exceeds the supply.

1952

502. Barish, Norman N., "Doctoral Study in Industrial Engineering." Jour. Eng. Educ. 42, 455-9 (May 1952).
503. Bergen, Martin J., "What Should a Technical Education Offer?" Pub. Util. Fortnightly 49, 802-5 (June 5, 1952).

There are four things the undergraduate should expect from a technical school:

1. A general but not universal knowledge of the language of science, through mathematics.
2. A knowledge of the general grammar of science through the study of sciences such as physics and chemistry.

3. Knowledge and proficiency in the application of both of these branches.
4. Mastery and proficiency in the graphical language of engineering.

504. Botset, Holbrook G., "Evaluating a Petroleum Engineering Curriculum." Jour. Petrol. Tech. 4, (Sec. 1), 23-4 (1952).

In addition to a background in science, economics, and humanities, the petroleum engineer needs specialized knowledge of geology and reservoir engineering. More highly specialized topics (e.g., well logging, mud-engineering) should be left to graduate study.

505. Hurlbut, L. W., "A General Curriculum for Agricultural Engineers." Jour. Eng. Educ. 42, 451-4 (May 1952).

The suggested curriculum is as follows:

Agriculture and agricultural engineering	41 hours
Mathematics	19
General engineering	24
Physics	10
Chemistry	6
English usage	9
Military	4
Non-technical options	15
Technical options	8
TOTAL	136 hours

The curriculum is believed to offer only limited specialization. A graduate program based on advanced technical material should be available for those who wish to specialize.

506. Lehman, E. W., "Agricultural Engineering Curriculum at the University of Illinois." Jour. Eng. Educ. 42, 286-90 (Jan. 1952).

507. Michaels, Alan S., "The Undergraduate Thesis in Chemical Engineering." Jour. Eng. Educ. 43, 90-4 (Oct. 1952).

508. Olyphant, M., Jr., "Plastics Training for Electrical Engineers." Jour. Soc. Plastics Engrs. 8, 41 (Dec. 1952).

Training for electrical engineers in plastics can probably be handled as well or better by industry than in an academic course. Only the highly specialized field of insulation and only a few other phases of the plastics field would attract electrical engineers.

509. Plank, William B., "An Estimate of the Success of the Five-Year Mineral Engineering Programs." Jour. Eng. Educ. 43, 103-6 (Oct. 1952).

510. Platt, Washington, "Can Present Curricula in Industrial, Administrative, Management Engineering, Etc., Be Unified Under One Title?" Jour. Eng. Educ. 43, 115-20 (Oct. 1952).

1951

511. Bartlett, B. W., "Nuclear Science and Engineering School Curricula." Nucleonics 8, 68-71 (May 1951).

There is no need for establishing nuclear engineering as a new branch. All engineers, however, should have some course work in nuclear science, and graduate training in nuclear engineering should be encouraged.

512. Beck, Clifford K., "The Undergraduate Nuclear Engineering Curriculum at North Carolina State College." Jour. Eng. Educ. 41, 378-82 (Mar. 1951).

The new curriculum in nuclear engineering, scheduled to begin in September 1951, is described. (The curriculum is divided as follows:

General education	26%
Basic science	32
Basic engineering	14
Nuclear technology	11
Technical electives	17

The curriculum was established on the basis of a large demand for nuclear engineers and the rapid growth of the industry.

513. Beck, Clifford K., "Undergraduate Nuclear Engineering Curriculum at North Carolina State College." Nucleonics 8, 54-9 (Jan 1951).

514. Brown, George Granger, "Graduate Education in Chemical Engineering." Chem. Eng. Prog. 47, 46 (Mar. 1951).

Objectives and minimum requirements of a graduate program in chemical engineering are outlined in general form.

515. Chyle, John J., "Need for Professional Training for the Welding Engineer." Welding Jour. 30, 245-6 (Mar. 1951).

A welding engineering curriculum is outlined in general form. After mentioning the prerequisites of mathematics, chemistry, and physics, and after calling for "streamlining" of machinery and materials courses, the author lists the many specialized courses needed by the welding engineer.

516. Davidson, Harold O., "The Graduate Program in Industrial Engineering at the Ohio State University. I. Graduate Work in Methods and Standards." Jour. Eng. Educ. 42, 217-9 (Dec. 1951).

517. Mitten, Loring G., "The Graduate Program in Industrial Engineering at the Ohio State University. II. Graduate Work in Quality and Production Control." Jour. Eng. Educ. 42, 219-21 (Dec. 1951).

518. Power, Harry H., "An Analysis of Petroleum Engineering Curricula, and Recommendations for Elective Sequences." Jour. Eng. Educ. 41, 300-7 (Jan. 1951).

A petroleum engineering curriculum should emphasize broad fundamental studies, the role of design and economics, good English, flexibility, and the importance of the five-year program.

519. Wyant, Robert A., "Professional Training for the Welding Engineer at the Rensselaer Polytechnic Institute." Welding Jour. 30, 243-4 (Mar. 1951).
520. Young, D. H., "The Development of a Graduate Program in Engineering Mechanics." Jour. Eng. Educ. 41, 528-32 (May 1951).

Stanford University's new program requires 45 quarter hours of course work (no thesis) for the M.S. degree in engineering mechanics. Of these 45 hours, six must be taken in elasticity, six in dynamics, six in fluid motion, and six in mathematics. Another 12 hours must be taken in mechanics electives, while nine are absolutely free electives.

The Ph.D. program requires two more years' work beyond the M.S., including a thesis. No minor is required, in line with what the author believes to be a trend. Narrow specialization is unavoidable in the Ph.D. program; the author believes that four years of undergraduate study should supply breadth of background.

1950

521. Bullinger, Clarence E., "The Place of Tool Engineering in an Industrial Engineering Curriculum." Jour. Eng. Educ. 40, 521-4 (May 1950).
522. Burns, R. M., "Qualifications of Chemical Engineers for Industrial Research." Jour. Eng. Educ. 40, 607-10 (June 1950).

Chemical engineering undergraduates who are training for research should be trained in fundamentals rather than specific processes.

Graduate training at the doctorate level is desirable for men who are to perform independent research. The Ph.D. thesis is not enough; a third of the student's time should be given to minor researches of varied nature.

523. Corrigan, Thomas E., "Results of Questionnaire Regarding Graduate Degrees in Chemical Engineering." Jour. Eng. Educ. 41, 170 (Nov. 1950).

On the basis of 23 replies, policies regarding formal requirements for graduate degrees in chemical engineering are compared among schools.

524. Crowther, John F., "The Chemical Engineering Senior as a Freshman in the Heavy Chemical Industry." Jour. Eng. Educ. 40, 536-9 (May 1950).

An industrial executive discusses the training needed by chemical engineers. Engineers going into industry would often spend their time better studying economics than extending their strictly technical studies. Writing is another neglected skill.

525. Gilkey, H. J., "A Curriculum Leading to the Bachelor's Degree in Engineering Mechanics." Jour. Eng. Educ. 40, 492-9 (May 1950).

The new engineering mechanics curriculum of Iowa State College is described.

The time has come, in the author's opinion, for a new engineering curriculum designed to strengthen basic training at the expense of specialization. This will inevitably be a curriculum in engineering mechanics or very close to it.

A proposed "curriculum in engineering" being considered at Iowa State is outlined as a case in point. The Purdue University civil engineering and engineering mechanics combined curriculum is also discussed.

526. Gray, J. B., "Teaching of Process Control Principles to Chemical Engineers." Instruments 23, 557-9 (June 1950).

The primary purpose of the Process Control Principles course at Syracuse University is "to develop an understanding of the behavior of typical processes or systems when controlled automatically."

Questions that such a course seeks to answer are:

1. Why control a process?
2. What is automatic control of a process?
3. What devices are available for measurement and control and how do they function?
4. What factors influence the behavior of a controlled process and in what way?

A complete outline of the course is presented.

527. Laitala, Everett, "What's New in Industrial Engineering Curricula? Jour. Eng. Educ. 40, 386-91 (Mar. 1950).

The only generally new area is statistical methods as applied to industrial problems. The major result of this survey (46 schools reporting) was to show the firm position of industrial engineering among the major branches of engineering.

528. Maslan, Frank D., "Nuclear Engineering Course at New York University." Nucleonics 7, 84-7 (Oct. 1950).

529. Plank, William B., "Diversification vs. Unification in Mineral Engineering Curricula." Mining Eng. 187, 347-8 (Mar. 1950).

The author of this paper expresses alarm over the extreme specialization of engineers related to the mineral field. The fact that over twenty varying types of degrees in "mineral" engineering are offered points up the need for a return to a more generalized curriculum. No particular recommendations are offered by the author.

530. Sherman, George W., "Purdue's Course in Engineering Instrumentation in the School of Chemical and Metallurgical Engineering." Instruments 23, 31-3 (Jan. 1950).

531. Sherwood, Thomas K., "Graduate Training in Chemical Engineering." Chem. Eng. News 28, 2648-50 (Aug. 7, 1950).

The purpose of graduate education is to give the student a better grasp of basic tools. An important requirement is that the student accomplish a creative objective.

There seems to be no major change in prospect for graduate programs for some years ahead.

The author, an M.I.T. professor, outlines the desirable content of a chemical engineering graduate program.

532. Thomas, F. H., "Industrial Engineering -- What Is It?" Jour. Eng. Educ. 40, 589-91 (June 1950).

ADDENDUM

1958

533. Brown, Bonner, and Weir, The Next One Hundred Years. New York: The Viking Press (1958).

1953

534. Taylor, Walter A., "Architectural Education." Higher Education 10, 17-27 (Oct. 1953).

Among architecture's current problems are (1) a lack of appreciation of research, (2) neglect of the sciences as relating to human reactions and therefore to design, (3) the difficulty of providing the breadth of education needed by architects, and (4) confusion regarding the meaning of "architectural engineering."

Since 1950 all accredited architecture curricula are five years in length. These include integrated curricula and the divided, or 2-3 curriculum.

Of 64 schools, only 25 offer a Master's degree, and only two (Harvard and Princeton) offer a doctorate in architecture. The few doctorates are usually taken in other subjects: history, engineering, etc.